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Modeling of Atmospheric Structure, 70-130 km

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A formulation is presented for modeling neutral atmosphere structure in an intermediate height region (70-130 km) between given lower and upper models in temperature, pressure, density and constituent gas concentrations and to maintain continuity in the second derivative of temperature and the other properties with respect to height.

The method employs temperature as the prime parameter requiring simultaneously a best fit to available temperature data at the intermediate heights and hydrostatic consistency between the nitrogen partial pressures at 70 and 130 km. The method is well suited to upper and lower models that have analytical representations and is developed in this report for MSIS-86 as the upper model and for polynomially-generated height-latitude cross-sections in the lower region.

Attention is given to comparisons between observed and model temperatures and it is found that mid-latitude data (primarily obtained using the incoherent scatter technique) are on average higher than the models due to the requirement to maintain hydrostatic (Contd)

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consistency in nitrogen partial pressures between the 70 km and 130 km values of the given lower and upper models. This discrepancy which at present remains an unresolved problem is discussed in the text. Tables of temperature, pressure, and density are included in the report based on the best fit to available data and simultaneously satisfying the constraints of the upper and lower models.

The tables presented are of diurnal and zonal mean values of temperature, pressure and density at 5-km height intervals from 70 to 130 km for each mid-month date and solar activity of $F_{10.7}$ = 70 and 150 units and geomagnetic activity of A_p = 4 and 132.

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1. INTRODUCTION

Season and latitude have traditionally been considered the major influence on the structure of the stratosphere and mesosphere. The Air Force Reference Atmospheres[1] tabulated temperature, density and pressure for each month and each 15° N latitude to 90 km altitude. CIRA 1972, Part 2 tabulated these parameters for each month and each 10° N latitude to 110 km. Tabulations to 80 km at monthly intervals have been extended to the southern hemisphere with a 10° latitude interval (Koshelkov,[2] Barnett,[3] Barnett and Corney[4]).

(Received for publication 15 June 1987)

1. Cole, A. E., and Kantor, A. J. (1978) Air Force Reference Atmospheres, Air Force Surveys in Geophysics, No. 382, AFGL-TR-78-0051, ADA 058505, Second Printing, Corrected edition, March 1984.
2. Koshelkov, Yu. P. (1983) Proposal for a reference model of the middle atmosphere of the southern hemisphere, Adv. Space Res. 3:3.
3. Barnett, J. J. (1984) Plots and Tables of Temperature and Geopotential Height Based on Nimbus 5 SCR and Nimbus 6 PMR, Working Group 4 Document, XXV COSPAR Meeting, Graz, Austria.
4. Barnett, J. J., and Corney, M. (1985) Middle atmosphere reference model derived from satellite data, in Handbook for MAP, 16:47, July 1985, SCOSTEP Secretariat, University of Illinois, 1406 W. Green Street, Urbana, IL 61801.

Additional dependences, notably local solar time and solar activity, are essential for modelling of the thermosphere as, for example, in CIRA 1972, Part 3 which extends upwards from 110 km. Further dependences are included in MSIS-83,[5] which extends upwards from 90 km.

The present report addresses itself to the problem of modelling the intermediate region between mesospheric and thermospheric models. It seeks to develop a procedure for generating a smooth transition between selected lower and upper models in all relevant neutral atmosphere parameters, including composition.

The need for improved modelling of the mesosphere/thermosphere region has long been evident and a 1984 recommendation for a new CIRA referred to the need for tabulations from 80 to 120 km. An altitude range from 70 to 130 km has been adopted for the present work to allow a smooth transition to be introduced to the lower and upper models, whose values are required to be matched at 70 and 130 km. The problem of modelling the 70 to 130 km region is therefore one of satisfying two types of conditions. One is imposed by the requirements of the upper and lower models and the other by the temperature data of the intermediate region. Such data are taken in the present work at 5 km height intervals, that is, at 75, 80, ..., 125 km. The problem is a novel one in atmospheric modelling in that the usual requirement is of the latter type, that is, to obtain a fit to a set of data. In the present problem, the requirement to also match lower and upper models in all their relevant parameters is not an independent one, and a particular matter of interest and concern is the extent to which both types of condition can be satisfactorily met. The treatment here is to rigidly match the lower and upper models (with continuity in the second height derivative) and at the same time optimize the fit to the intermediate temperature data, which may show a residual bias due to the rigid end constraints. In previous works by Forbes and Groves,[6] the temperature data were found to be biased higher than model values and the matter warranted further consideration.

The procedure of model formulation is described in Appendix A and relates to the choice of MSIS-86[7] for the upper model and to that described in 'A Global Reference Atmosphere From 18 to 80 km'[8] for the lower model. A report of the

5. Hedin, A. (1983) A revised thermospheric model based on mass spectrometer and incoherent scatter data, MSIS-83, J. Geophys. Res. 88:10170.

6. Forbes, J.M., and Groves, G.V. (1986) Atmospheric Structure between 80 and 120 km, presented to Workshop No. XV, XXVI COSPAR Meeting, Toulouse, France.

7. Hedin, A. (1986) CIRA 1986 Atmospheric Model in the Region 90 to 2000 km, Draft of 18 June 1986.

8. Groves, G.V. (1985) A Global Reference Atmosphere From 18 to 80 km, Air Force Surveys in Geophysics, No. 448, AFGL-TR-85-0129, ADA 162499.

earlier calculations undertaken at a preliminary stage of this work with MSIS-83 as the upper model has been given previously.[6] The subsequent stages then proposed for the formulation have now been completed and are reported here. These include (a) modelling of individual constituent gases and hence of total density and pressure, (b) combining the three models for the height regions 18 to 70, 70 to 130 and above 130 km to provide a single model from 18 km upwards (Appendix D, Section 3), and (c) the development of models for various solar conditions (and not only mean solar conditions as treated earlier.)

2. TEMPERATURE DATA UTILIZED, 70 TO 130 km

Temperature data have been assembled from two earlier collations of data, that is, from that used for the construction of CIRA 1972, Part 2 and the rocket and incoherent scatter (I.S.) data reviewed by Forbes.[9] Analyses of I.S. data from St. Santin[10] have also been utilized.

I.S. temperatures were utilized as monthly means for the locations and heights shown in Table 1 and were compared with models computed for the solar activity parameters shown in the table.

Table 1. Distribution of Available Monthly Mean I.S. Temperatures

Site	Height km	Solar Activity $F_{10.7} = \bar{F}_{10.7}$	A_p
Millstone Hill (42 N) (Wand,[11] Table 1)	105-125	120	7
St. Santin (45 N) (Alcaydé et al,[10] Table 1)	95-110, 120	70, 120, 170	7
Arecibo (18 N) (1970-1975 data, Forbes[9])	105-130	108	10

9. Forbes, J.M. (1984) Temperature Structure of the 80 km to 120 km Region, presented at the XXV COSPAR Meeting, Graz, Austria.

10. Alcaydé, D. et al (1979) Temperature, molecular nitrogen concentration and turbulence in the lower thermosphere inferred from incoherent scatter data, Ann. Geophys. 35:41.

11. Wand, R.H. (1983) Lower thermospheric structure from Millstone Hill incoherent scatter radar measurements 2. Semidiurnal temperature component, J. Geophys. Res. 88:7211.

Monthly mean temperatures from rocket techniques were utilized for the locations and heights shown in Table 2. The Kwajalein data of 1976-1978 have been compared with models computed for $F_{10.7} = \bar{F}_{10.7} = 95$ units. For the other data, which extend no higher than 100 km, solar effects are minimal and a value of $F_{10.7} = \bar{F}_{10.7} = 120$ units has been adopted for computing models for comparison purposes. Likewise a mean value of A_p (= 10) has been adopted in model computations.

Table 2. Distribution of Monthly Mean Temperatures Obtained by Rocket Techniques

Site	Height km	Site	Height km
Heiss Is. (81 N)	75-100	Thumba (8 N)	75
Volgograd (48 N)	75-100	Ships (equator)	75-100
Kwajalein (9 N)	75-120	Molodezhnaya (68 N)	75-80

The locations at which single rocket profiles of temperature were utilized are shown in Table 3. The data available fall off rapidly above 100 km as shown in Table 3 by the numbers of profiles available at 105 and 120 km. Single profiles are compared with models computed for the same solar activity parameters as defined by the procedure described in Appendix B.

Table 3. Numbers of Available Temperature Data at 105 and 120 km From Rocket Launchings

Site	Height (km) 105	120	Site	Height (km) 105	120	Site	Height (km) 105	120
Pt Barrow (71 N)	3	0	Wallops (38 N)	18	16	Barking S (22 N)	3	0
Churchill (59 N)	8	5	White S (32 N)	8	0	Kwajalein (9 N)*	3	2
Sardinia (44 N)	0	1	Eglin (30 N)	6	1	Ascension (8 S)	2	0

*Developed into a monthly model (Cole et al[12]) and listed in Table 2.

12. Cole, A.E., Kantor, A.J., and Philbrick, C.R. (1979) Kwajalein Reference Atmospheres, 1979, Environmental Research Papers, No. 677, AFGL-TR-79-0241, ADA 081780.

3. MODEL FORMULATION, 70 TO 130 km

The procedure devised for calculating a model temperature profile from 70 to 130 km is set out, step-by-step, in Appendix A. Theoretical details are presented in Appendixes A1 to A5. An essential feature of the method is the expression, for given geophysical conditions, of g/T (g being gravity acceleration and T temperature) as a polynomial in height whose coefficients are chosen (a) to give continuity up to the second height derivative with the lower and upper models, (b) to reproduce, on integration of appropriate physical equations, the required ratio of N_2 pressure at 70 km to that at 130 km, and (c) to produce a best fit to observed temperatures at 75, 80, ..., 125 km altitude.

Appendix A sets out the step-by-step procedure for calculating density. The method is based on the MSIS-86[7] formulation for number densities of individual gas constituents. Other parameters then follow as set out in Appendix A.

4. COMPARISON OF OBSERVED TEMPERATURES WITH MODELS

This section analyzes the differences between observed temperatures and model values computed in each case for the same geophysical conditions. Model values are derived by the procedure of Appendix A which involves polynomial coefficients a_{sn} whose determination depends on the analysis of temperature data as described in Appendix B.

Three cases with different selections of temperature data have been considered and a set of coefficients a_{sn} corresponding to the second of these cases is listed in Appendix B.

4.1 Case 1: a_{sn} Based on All Data Excluding Millstone Hill

Case 1 was undertaken in the preliminary investigation[6] which utilized all data at first and then excluded Millstone Hill data because of their relatively high values. The comparisons reported in Sections 4.1.1 to 4.1.3 essentially repeat and update the results previously given.

4.1.1 a_{sn} AT LOW LATITUDES BASED ON ALL DATA

The first two columns of Table 4 shows the average deviations from the computed models of temperature data for all months at Kwajalein (9 N) and Arecibo (18 N). Such deviations are denoted by x_i (for the i th site) in Appendix C which presents the relations used in the analysis. Kwajalein and Arecibo provide the main input of data above 100 km at low latitude and as previously noted by Forbes and Groves,[6] the Kwajalein temperatures are lower than those of Arecibo by about 15 K on average.

Table 4. Low Latitude Temperature Differences From Computed Model Values (K). Av = average difference for data of all months at a particular site. Case 1

Height	Kwajalein		Arecibo		Ships (equator)		All sites*	
km	Av	sd	Av	sd	Av	sd	Mean of Av	sd
75	-1.4	1.3	-	-	-0.5	1.6	-0.5	1.7
80	2.4	0.8	-	-	-3.3	1.2	1.4	1.5
85	5.9	0.8	-	-	-6.5	1.0	1.8	3.2
90	6.9	0.7	-	-	-6.0	1.2	3.8	2.8
95	3.9	0.8	-	-	-1.7	2.1	3.3	1.7
100	-4.4	0.9	-	-	9.3	4.6	-3.5	2.6
105	-8.0	1.8	9.9	5.2	-	-	-3.5	13.0
110	1.4	1.3	13.9	5.6	-	-	2.1	3.5
115	10.3	3.9	23.0	6.1	-	-	14.0	8.2
120	-9.8	2.7	7.6	4.6	-	-	-5.3	10.7
125	-	-	-10.8	7.0	-	-	-10.8	7.0**

*Ascension Is. (8 S), Natal (6 S), Ships (equator), Kourou (5 N), Thumba (8 N), Kwajalein (9 N), Arecibo (18 N), Barking Sands (22 N), Carnarvon (25 S).

**Arecibo data only.

An unsatisfactory latitude variation at low latitudes was modeled in the preliminary work[6] by closely fitting to these data. The difficulty has been overcome in the present work by increasing the degree of smoothing to give models with an acceptable latitude structure at low latitude. The lower Kwajalein temperatures then lead to lower differences as shown for 105 to 120 km in Table 4.

In the last column of Table 4 are the mean values $(\bar{x})$, where the mean is taken over all sites appropriately weighted. The 11 means at 75, ..., 125 km are both positive and negative with a weighted average of about 1 K. A 1 K change over the height range 70 to 130 km is equivalent to a 4 percent change in the ratio of N_2 pressures at 70 and 130 km. Such changes would be within the expected limits of accuracy and therefore the intermediate temperature data, taken as a whole over all sites, are not inconsistent with the lower and upper models. Data for a particular site may nevertheless still be biased one way or the other with respect to the models, for example, Arecibo data at 105 to 120 km show a region of bias to higher temperatures by about 10 to 20 K.

4.1.2 a_{sn} AT MIDDLE LATITUDES BASED ON ALL DATA EXCLUDING MILLSTONE HILL

Table 5 presents average temperature differences from computed models for the five middle latitude sites that contribute most data at heights above 100 km. The mean of such averages with respect to all sites from 30° to 50° latitude is also shown. In contrast to the results of Table 4, model values are consistently lower than observed temperatures. Such a bias was noted and reported at the preliminary stage of this work[6] and is able to arise as the least-squares fit is constrained by the requirement to match the N_2 pressures of the lower and upper models at 70 and 130 km.

Table 5. Middle Latitude Temperature Differences From Computed Models (K). Av = average difference for data of all months at a particular site. Case 1

Height	Eglin		White Sands		Wallops		St. Santin		Millstone Hill		All sites*	
km	Av	sd	Av	sd	Av	sd	Av	sd	Av	sd	Mean of Av	sd
75	-2	2	9	4	2	1	-	-	-	-	0.3	1.1
80	1	4	9	4	0	2	-	-	-	-	1.1	0.9
85	2	3	3	5	3	2	-	-	-	-	5.8	1.7
90	11	3	4	4	8	2	-	-	-	-	10.2	1.9
95	20	6	15	5	14	4	8	1	-	-	9.8	1.5
100	24	7	21	7	13	5	1	1	-	-	6.1	5.1
105	24	4	27	8	5	5	3	1	22	1	13.2	6.2
110	46	19	14	8	7	10	10	2	38	3	24.5	12.0
115	-	-	-	-	54	14	-	-	49	3	48.9	1.6
120	-	-	-	-	48	18	32	3	39	3	35.9	4.6
125	-	-	-	-	27	25	-	-	13	2	12.8	1.5

*Eglin (30 N), Woomera (31 S), White Sands (32 N), Arenosillo (37 N), Wallops (38 N), Millstone Hill (42 N), Sardinia (44 N), St. Santin (45 N), Volgograd (48 N), Kerguelen (49 S).

If we consider the changes that would be needed in the models at 70 or 130 km to enable the intermediate model temperatures to fit observed values we find that either (a) pressures at 70 km would need to be lower by 40 percent or (b) pressures at 130 km would need to be higher by 40 percent or (c) corresponding partial adjustments would need to be made at both heights. Such pressure adjustments would require lower temperatures over some range of height in either or both of the lower and upper models thereby allowing higher values to be modeled in the intermediate region. The discrepancy between observed and model values is discussed in Section 7.

4.1.3 a_{sn} AT HIGH LATITUDES BASED ON ALL DATA

Table 6 shows average temperature differences from computed models for three high latitude sites. Data are available from few sites at high latitude and then mainly below 105 km. As would be expected in these circumstances, no difficulty arises in deriving models that are consistent with the limited height range of available data.

Table 6. High Latitude Temperature Differences From Computed Models (K). Av = average difference for data of all months at a particular site. Case 1

Height	Churchill		Pt. Barrow		Heiss Is.		All sites*	
km	Av	sd	Av	sd	Av	sd	Mean of Av	sd
75	3.6	1.6	-1.4	2.2	0.3	1.3	-1.4	3.1
80	-0.2	1.9	-0.4	2.4	0.6	1.8	-1.1	1.4
85	0.4	1.7	-0.2	3.0	0.7	1.6	0.5	0.4
90	5.8	3.1	6.7	2.8	-1.7	2.0	2.1	4.9
95	11.2	4.6	15.7	8.3	-5.8	2.7	-0.2	10.3
100	14.2	4.1	-7.6	13.1	-13.2	2.8	-4.6	15.4
105	12.0	7.4	-24.8	3.6	-	-	-17.8	20.5
110	6.0	13.3	-	-	-	-	6.0	13.3**
115	26.3	19.7	-	-	-	-	26.3	19.7**
120	47.3	32.3	-	-	-	-	47.3	32.3**
125	-	-	-	-	-	-	-	-

*Churchill (59 N), Molodezhnaya (68 S), Pt. Barrow (71 N), Heiss Is. (81 N).

**Churchill data only.

Table 6 shows the mean of the average differences with respect to the few existing high latitude sites. The absence among these means of any significant difference from zero is a result of the paucity of data above 100 km.

4.2 Case 2: a_{sn} Determined Without I.S. Data and Without Data From 105 to 125 km

By excluding data above 100 km from the analysis of Appendix B and the determination of a_{sn}, we can expect to compute models that have a better fit to data at and below 100 km at the expense of having a poorer fit to the excluded data above 100 km. Comparisons between observed and computed temperatures are presented for the same groups of low, middle and high latitude sites as for Case 1. Data are much more numerous below 100 km than above and for this reason Case 2 is worthy of investigation.

4.2.1 a_{sn} AT LOW LATITUDES DETERMINED WITHOUT I.S. DATA AND WITHOUT DATA FROM 105-125 km

Table 7 presents the results for Case 2 corresponding to those for Case 1 in Table 4. As would be expected, model temperatures at 110 - 125 km are now lower (by ~ 10 K) and those at 85 - 100 km are higher (by ~ 2 K). These changes are generally significant for any particular site but over all sites the last columns of Tables 4 and 7 show that the changes in the means (which are also ~ 10 K and 2K in the respective height ranges) are not significant, being of the same order of magnitude as the standard deviations (sd) of the means.

The fact that omission of data above 100 km results in such a limited change, on average, in the modeling accords with the conclusion of Section 4.1.1 that observed temperatures for 75 - 125 km are not inconsistent with the lower and upper models when taken as a whole over all sites.

For individual sites, the average differences between observed and computed temperatures may be significantly increased or decreased for Case 2 relative to Case 1. For Arecibo, observed values at 110 - 120 km are now higher than computed values by 30 - 40 K.

Table 7. Low Latitude Temperature Differences From Computed Model Values (K). Av = average difference for data of all months at a particular site. Case 2

Height	Kwajalein		Arecibo		Ships (equator)		All sites * Mean of	
km	Av	sd	Av	sd	Av	sd	Av	sd
75	-1.3	1.3	-	-	-0.5	1.6	-0.4	1.7
80	2.5	0.8	-	-	-3.7	1.1	1.1	1.6
85	4.8	0.7	-	-	-7.5	0.9	0.4	3.2
90	4.2	0.5	-	-	-7.8	1.0	1.7	2.5
95	0.4	0.8	-	-	-3.6	1.8	-0.1	1.4
100	-7.1	1.0	-	-	8.1	4.3	-6.2	2.8
105	-8.0	1.9	9.3	5.7	-	-	-2.8	14.9
110	5.4	1.3	23.3	5.8	-	-	6.4	4.9
115	18.6	4.0	42.3	6.2	-	-	25.6	15.3
120	-0.7	2.7	29.9	5.3	-	-	5.6	17.5
125	-	-	-2.1	6.8	-	-	-2.1	6.8**

*Ascension Is. (8 S), Natal (6 S), Ships (equator), Kourou (5 N), Thumba (8 N), Kwajalein (9 N), Arecibo (18 N), Barking Sands (22 N), Carnarvon (25 S)

**Arecibo data only.

4.2.2 a_{sn} AT MIDDLE LATITUDES DETERMINED WITHOUT I.S. DATA AND WITHOUT DATA FROM 105-125 km

Table 8 presents average differences for Case 2 corresponding to Table 5 for Case 1. As expected, the fit up to 100 km is much improved with both positive and negative average differences whose means over all sites are now not significantly different from zero (the last column of Table 8).

Above 100 km the high average differences of Table 5 become still higher for Case 2 being ~80 K at 115 - 120 km.

At middle latitudes, Cases 1 and 2 present straight choices between models that are biased lower than observations at all heights, 75 - 125 km, (Case 1) and those that are biased lower than observations at only 105 - 125 km (Case 2), the biases nevertheless being significantly greater.

Table 8. Middle Latitude Temperature Differences From Computed Models (K). Av = average difference for data of all months at a particular site. Case 2

Height	Eglin		White Sands		Wallops		St. Santin		Millstone Hill		All sites* Mean of	
km	Av	sd	Av	sd	Av	sd	Av	sd	Av	sd	Av	sd
75	-1	2	10	4	3	1	-	-	-	-	1.0	1.0
80	2	4	9	4	1	1	-	-	-	-	2.0	0.9
85	-2	3	-1	5	0	2	-	-	-	-	2.1	1.8
90	-1	3	-6	4	-3	2	-	-	-	-	-0.3	1.6
95	3	5	2	4	-1	4	-6	1	-	-	-2.9	2.0
100	11	7	11	6	1	5	-11	1	-	-	-5.7	5.3
105	23	4	26	8	4	5	1	1	21	1	13.8	6.0
110	62	19	28	9	25	10	23	2	53	2	42.4	12.8
115	-	-	-	-	91	14	-	-	80	3	80.8	2.9
120	-	-	-	-	90	17	65	3	75	3	69.9	6.3
125	-	-	-	-	45	25	-	-	27	2	27.2	1.7

*Eglin (30 N), Woomera (31 S), White Sands (32 N), Arenosillo (37 N), Wallops (39 N), Millstone Hill (42 N), Sardinia (44 N), St. Santin (45 N), Volgograd (48 N), Kerguelen (49 S)

4.2.3 a_{sn} AT HIGH LATITUDES DETERMINED WITHOUT I.S. DATA AND WITHOUT DATA FROM 105-125 km

Table 9 shows average differences at high latitude sites when data at 105 km and above are omitted from the determination of a_{sn}. At 110 km and above the omitted data amount to only eight rocket temperature profiles at Churchill (59 N) and hence Table 9 shows no significant change from Table 6, being given here for the sake of completeness.

Table 9. High Latitude Temperature Differences From Computed Models (K). Av = average difference for data of all months at a particular site. Case 2

Height	Churchill		Pt. Barrow		Heiss Is.		All Sites* Mean of	
km	Av	sd	Av	sd	Av	sd	Av	sd
75	4.3	1.6	-1.2	2.2	0.2	1.3	-1.2	3.2
80	1.5	1.9	0.3	2.4	0.4	1.8	-0.3	1.4
85	0.4	1.7	0.0	3.0	0.6	1.6	0.4	0.2
90	1.9	3.0	5.9	2.8	-1.6	2.0	1.2	3.9
95	3.9	4.7	14.2	8.2	-5.3	2.7	-1.7	7.3
100	7.5	4.2	-9.3	13.1	-12.7	2.8	-6.6	11.3
105	9.4	7.6	-25.7	3.6	-	-	-19.3	19.2
110	10.8	13.6	-	-	-	-	10.8	13.6**
115	40.0	19.9	-	-	-	-	40.0	19.9**
120	64.3	32.1	-	-	-	-	64.3	32.1**
125	-	-	-	-	-	-	-	-

*Churchill (59 N), Molodezhnaya (68 S), Pt. Barrow (71 N), Heiss Is. (81 N).

**Churchill data only.

4.3 Case 3: a_{sn} Determined Without Data at 75 to 95 km

In this case, all data at heights 100 - 125 km, including incoherent scatter data from Arecibo, Millstone Hill and St. Santin have been utilized for determining a_{sn} according to the procedure of Appendix B, while that below 100 km have been omitted. In comparison with Cases 1 and 2 an improvement in the fit of computed temperatures to observed values can be expected above 100 km at the expense of lower computed temperatures and a poorer fit to observations below 100 km.

Table 10 shows the results obtained for mid-latitude data corresponding to Tables 4 and 7 for Cases 1 and 2. At 85 - 95 km, Table 10 shows the temperatures are ~20 K higher than model values. In comparison, the difference is ~10 K for Case 1, but differences above 100 km are greater. Case 2 produces a close fit at 85 - 95 km with still larger differences above 100 km.

Table 10. Middle Latitude Temperature Differences From Computed Models (K). Av = average difference for data of all months at a particular site. Case 3

Height	Eglin		White Sands		Wallops		St. Santin		Millstone Hill		All Sites* Mean of	
km	Av	sd	Av	sd	Av	sd	Av	sd	Av	sd	Av	sd
75	0	2	12	4	5	1	-	-	-	-	2.6	1.2
80	10	4	20	4	11	2	-	-	-	-	10.8	1.0
85	16	3	19	5	19	2	-	-	-	-	20.3	1.7
90	23	3	18	4	23	2	-	-	-	-	23.4	1.9
95	25	5	21	5	22	4	16	1	-	-	18.5	1.6
100	19	7	17	7	10	5	-1	1	-	-	4.4	5.3
105	10	4	10	8	-12	5	-12	1	6	2	-6.5	5.7
110	23	18	-14	8	-23	9	-19	2	8	4	-2.4	14.1
115	-	-	-	-	19	12	-	-	13	4	13.3	2.6
120	-	-	-	-	23	16	6	4	13	4	9.9	5.3
125	-	-	-	-	22	25	-	-	6	1	5.9	1.3

*Eglin (30N), Woomera (31S), White Sands (32N), Arenosillo (37N), Wallops (38N), Millstone Hill (42N), Sardinia (44N), St. Santin (45N), Volgograd (48N), Kerguelen (49S)

5. TABULATIONS OF TEMPERATURE, PRESSURE AND DENSITY

A wide choice of options is open for the particular models to present as tables and for the format in which they are to appear. The choice involves the height interval of tabulation and many geophysical parameters.

Diurnal and zonal mean values have been tabulated in the course of this project as latitudinal-height cross-sections for solar activity parameters $F_{10.7}$ = 70 and 150 units and A_p = 4 and 132.

Two formats have been adopted and coded (Appendix D, Section 3). By taking a 5-km height interval (70 - 130 km) and 20° latitude interval (80S to 80N) in the program TVAL5KMP, 12 tables consisting of temperature, pressure and density cross-sections for four selected months are generated that fit together on one page. Such tables are presented in Appendix F for all months based on Case 1 determinations of a_{sn} and four cases of solar activity: $F_{10.7}$ = 70, 150 units, A_p = 4, 132.

By taking a 1-km height interval and 10° latitude interval from 80S to 80N in program TVAL1KMP, tables are generated with a format identical with that previously used (Groves[8]) for 18 - 80 km with each table occupying one page. Both programs generate tables of W - E geostrophic wind.

6. LIMITATIONS OF THE MODEL FORMULATION, 70 TO 130 km

6.1 Types of Data

The only type of data that has been utilized at heights 75 - 125 km is temperature, which has served both as an input to the formulation of the models for these heights and for comparison with the computed models to check their goodness-of-fit. A computed composition is available from the formulation, but density data have not been utilized either as an input to the formulation or to check against computed values. No check has been made between W - E winds computed from the geostrophic wind equation and observed values.

6.2 Local Solar Time

No representation of tidal components at 70 - 130 km is included in the formulation. At 130 km, dependence on L. S. T. is that defined by MSIS-86 while, at 70 km, the lower model is independent of L. S. T. At intermediate heights the L. S. T. dependence arises by interpolation while ignoring tidal fields that may have detailed spatial structures.

6.3 Longitude and Solar Activity Effects

No detailed representation of longitudinal variations at 70 - 130 km is included in the formulation. At 70 and 130 km, the dependences on longitude are those of the adjacent lower and upper models and, relative to other variations at these heights, are very small. At intermediate heights, longitude dependence is then generated by interpolation and is a correspondingly small effect.

Dependence on solar activity is also not directly represented at heights between 70 and 130 km, but is present in the interpolation between these two heights where it is represented.

6.4 The Coefficients a_{sn}

Sets of polynomial coefficients a_{sn} ($s = 1, \ldots, S$; $n = 1, \ldots, N$) are introduced by which height-latitude cross-sections of atmospheric structure parameters may be generated from 70 to 130 km at all latitudes. Subscript n is associated with a polynomial in height and subscript s with a polynomial in sin(latitude). Lack of data limits the number of sets of coefficients determined to 12, one for each month of the year. In principle, additional sets could be introduced with dependences on L.S.T., longitude, and solar activity to help overcome the limitations mentioned in Sections 6.2 and 6.3, but a vastly greater amount of data than that available would be required.

After many test computations with different choices of N and S, the choice was made of N = 2 and S = 7, giving 14 coefficients per set. Without improvements in the quality and quantity of available temperature profiles and their latitude distribution, N and S could not be justifiably increased.

Since a_{sn} relate to a pole-to-pole representation, they provide a means of formulating seasonal asymmetries between N and S hemispheres. Unfortunately observations are not available for much of the S hemisphere and it becomes necessary to assume seasonal symmetry for latitudes where observations are lacking in the determination of a_{sn} (Appendix B).

7. DISCUSSION

The modeling of atmospheric properties in an intermediate height region (70 - 130 km) between given mesospheric and thermospheric models has been treated theoretically (Appendixes A, A1 to A5, and B) and computationally as summarized in Appendixes D, E and F.

Temperature data (at 75, 80, ..., 125 km) that are utilized for modeling the intermediate region are summarized in Section 2 and two formats that have been devised for tabulating models of temperature, pressure and density, are outlined in Section 5 with examples given in Appendix F.

Section 4 presents comparisons between observed temperatures (75 - 125 km) and model values and is a section that commands particular attention on account of biases between the two that point to a possible inconsistency between the observed temperatures (75 - 125 km) and the given lower and upper models that are matched at 70 and 130 km. The biases feature strongly at mid-latitudes, where the majority of available data have been obtained, and are in the sense that observed values are higher than model values (Case 1 and Table 5).

One way in which the discrepancy could be resolved would be by modifying the N_2 pressures of the lower and upper models at one or both of the heights 70 and 130 km. The magnitude of the discrepancy is such that its removal would require a 40 percent change in the N_2 pressure ratio for these two heights and, as only a few percent adjustment could reasonably be allowed at 70 km, the majority of it would need to be applied at 130 km.

Another possible conclusion is that observed temperatures are erroneously high over at least some part of the 70 - 130 km height region. Above 100 km, temperature data are provided by the I.S. technique and a small number of measurements by rocket techniques as summarized in Tables 1 to 3. Up to 100 km, rocket data are much more numerous and are obtained by well-established techniques, such as the grenade experiment. Case 2 (Section 4.2) was therefore introduced to provide models that are consistent with the data at least up to 100 km (Table 8). However, the closer fit up to 100 km is obtained at the expense of a poorer fit above 100 km as shown in Table 8, where biases at 115 - 120 km are close to 80K for both I.S. measurements at Millstone Hill and St. Santin as well as rocket techniques at Wallops.

Support for high I.S. temperatures is provided by Arecibo data (18 N) as shown in Table 7, where biases at 115 - 120 km are about 30 - 40K, that is, about half those at mid-latitudes. The presence of a small component of high energy electrons would give I.S. temperatures in excess of neutral gas temperatures and could possibly account for the discrepancy. The presence of a similar bias in the rocket measurements at Wallops (Table 8), which at 120 km amount to 16 in number (Table 3), means that the discrepancy is unlikely to be solely attributable to biased I.S. temperatures. In particular, the possibility of adjusting to higher N_2 pressures at 130 km should be considered, as by that means higher model temperatures at 115 - 120 km would result and reduce the discrepancy whatever the method of measurement.

Finally, the contrary view to that represented by Case 2 might be taken, namely that the inconsistency is attributable to observed temperatures below 100 km being too high. Case 3 therefore computes temperature models by fitting to data at and above 100 km only and in so doing generates values at 85 - 95 km that are on average ~ 20 K lower than observed values (Table 10). At these heights, temperatures have been measured by the grenade, falling sphere and pitot pressure techniques, which are well-established methods that would not be expected to be consistently biased by more than a few degrees K and certainly not by as much as 20 K. Case 3 is not therefore considered to provide an acceptable model.

No positive recommendation for acceptable models of the intermediate (70 - 130 km) height range has been reached in the above investigations on account of consistent differences between temperature data and the possible models that can be computed with matching conditions at 70 and 130 km. One source of such differences between data and models could be the method of model formulation, and the possibility of incompletely formulated dependences on L. S. T., longitude, and solar activity is pointed out in Section 6. The differences, however, appear to have no consistent relationship with these dependences and are much greater in magnitude than any expected shortcomings in the formulation with respect to these dependences.

Attention therefore needs to be given to the possibility of observed values of temperature being overestimated. Case 2 has been devised to fit observed temperatures closely up to 100 km, but in so doing it provides models above 100 km that are less than observed mid-latitude values by ~80K at 115 - 120 km (Table 8) in order to match boundary conditions at 70 and 130 km. There may be scope for reducing the ~80K difference at 115 - 120 km by revising MSIS-86 at 130 km—the region from 130 to, say, 150 km being poorly observed—but the general nature of the inconsistency, that is, observed temperatures in excess of model values, would still remain.

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Appendix A

Model Formulation

A1. TEMPERATURE

At height z in the range (z_1, z_2) where $z_1 \leqq 80$ km (80 km being the upper limit of the lower model[A1] and $z_2 \geqq 90$ km (90 km being the lower limit of the upper model[A2]), we write

$$T = (M_{z_1}\, g/R)\, W \tag{A1}$$

where W is a function of height whose determination is the central consideration of the model formulation. g is acceleration due to gravity, R the universal gas constant and M_{z_1} the mean molecular weight of air as given by the lower model at height z_1.

As R may have (slightly) different values for any given lower and upper models and, likewise, g may be represented by different expressions in the two models, the values of R and g at height z are based on a smooth transition from R_1, $g_1(z)$ for the lower model to R_2, $g_2(z)$ for the upper model according to the relations

A1. Groves, G. V. (1985) A Global Reference Atmosphere From 18 to 80 km, Air Force Surveys in Geophysics, No. 448, AFGL-TR-85-0129, ADA 162499.

A2. Hedin, A. CIRA 1986 Atmospheric Model in the Region 90 to 2000 km, Draft of 18 June 1986.

$$R = \frac{1}{2}[R_1 + R_2 + (R_2 - R_1)\tanh c\zeta] \tag{A2}$$

$$(-1 \leqq \zeta \leqq 1)$$

$$g = \frac{1}{2}[g_1 + g_2 + (g_2 - g_1)\tanh c\zeta] \tag{A3}$$

where

$$c = 10 \tag{A4}$$

$$\zeta = (z - z_a)/z_d, \quad z_a = \frac{1}{2}(z_1 + z_2), \quad z_d = \frac{1}{2}(z_2 - z_1) \ . \tag{A5}$$

With c = 10, the accuracy at $\zeta = \pm 1$ is better than 1 in 10^{-8}. The lower and upper models provide:

$$M_{z_1} = 28.9644 \text{ kg (k mol)}^{-1}, \quad R_1 = 8.31432 \times 10^3, \quad R_2 = 8.314 \times 10^3 \text{ JK}^{-1} \text{(k mol)}^{-1} \tag{A6}$$

$$g_1 = g_\phi/(1 + z/r_\varphi)^2 \text{ at latitude } \phi \tag{A7}$$

$$g_\phi = 9.780356 \, (1 + 0.0052885 \sin^2\varphi - 0.0000059 \sin^2 2\phi) \quad (\text{ms}^{-2}) \tag{A8}$$

$$r_\varphi = 2 \times 10^3 \, g_\phi/(3.08546 + 0.00227 \cos 2\phi) \quad (\text{km}) \tag{A9}$$

$$g_2 = g_s/(1 + z/R_r)^2 \tag{A10}$$

where

$$g_s = 9.80665 \text{ m s}^{-2}, \qquad R_r = 6356.77 \text{ km} \ . \tag{A11}$$

(It may be noted that, if the mean molecular weight of air is constant for $z \leqq z_1$, W is pressure scale height (km) for $z \leqq z_1$.)

For $z_1 \leqq z \leqq z_2$, we express

$$W^{-1} = A + B \qquad (\text{km}^{-1}) \tag{A12}$$

where A and B are polynomials in ζ. B is an interpolating polynomial which depends only on conditions at height z_1 and z_2, as defined by the particular lower and upper models under consideration, and is otherwise independent of conditions relating to the interval (z_1, z_2). The conditions imposed at heights z_1 and z_2 are however such (see below) that B may be considered to provide a first approximation to W^{-1}.

A is an 'adjusting' polynomial whose determination is independent of conditions at heights z_1 and z_2 being dependent on temperature observations in (z_1, z_2) or more correctly on the differences between values of W^{-1} calculated by Eq. (A1) from available temperature values and B calculated for the same geophysical conditions (of date, location, solar activity, and so on).

We take A and its first two height derivatives to be zero at heights z_1 and z_2 by expressing it as

$$A = (1 - \zeta^2)^3 \sum_{s=1}^{7} \sum_{n=1}^{2} a_{sn} (\zeta^n - \gamma_n)\, \xi^{s-1} \; ; \; \xi = \sin\varphi \, . \tag{A13}$$

We choose $\gamma_1 = 0$, $\gamma_2 = 1/9$ as explained in Appendix A1. The determination of a_{sn} is described in Appendix B, where values of a_{sn} are tabulated.

B is determined by seven conditions involving model values at heights z_1 and z_2 and is therefore taken as a polynomial of degree 6 in ζ

$$B = b_1 + b_2 \zeta + \ldots . + b_7 \zeta^6 = [1 \; \zeta \ldots \zeta^6] \, \underline{b} \tag{A14}$$

where $\underline{b} = [b_1 b_2 \ldots b_7]'$. Six of the conditions are for continuity of W^{-1} (and hence of T) and of its first and second height derivatives at heights z_1 and z_2. The seventh condition is that the ratio of the N_2 pressures at z_1 and z_2 as calculated from the model temperature profile should equal that of the N_2 pressures specified by the lower and upper models at z_1 and z_2. We write (Appendix A1)

$$\underline{b} = \underline{S}\,\underline{\ell} \qquad (\mathrm{km}^{-1}) \tag{A15}$$

where

$$\underline{S} = \begin{bmatrix} 105 & -57 & -57 & -12 & 12 & -1 & 1 \\ 0 & -90 & 90 & -42 & -42 & -6 & 6 \\ -315 & 315 & 315 & 90 & -90 & 9 & 9 \\ 0 & 60 & -60 & 60 & 60 & 12 & -12 \\ 315 & -315 & -315 & -120 & 120 & -15 & -15 \\ 0 & -18 & 18 & -18 & -18 & -6 & 6 \\ -105 & 105 & 105 & 42 & -42 & 7 & 7 \end{bmatrix} \div 96 \tag{A16}$$

$$\underline{\ell} = [\ell_1 \ldots \ell_7]' \quad (\mathrm{km}^{-1}) \; . \tag{A17}$$

For the conditions at height z_1, we have (Appendix A2)

$$\ell_2 = h_1/D_1 + \Delta_1 \tag{A18}$$

$$\ell_4 = (D_2/D_1^2 + \Delta_2) z_d \tag{A19}$$

$$\ell_6 = [(D_1 D_3 + 2 D_2^2)/(h_1 D_1^3) + \Delta_3] z_d^2 \tag{A20}$$

$$D_1 = 1 + q_1 \tag{A21}$$

$$D_2 = h_2 - q_2 \tag{A22}$$

$$D_3 = h_1 h_3 - 2 h_2^2 - q_3 \tag{A23}$$

$$h_r = [d^{r-1}(H_{ref}^{-1})/dz^{r-1}]_{z_1} \qquad (r = 1, 2, 3) \; . \tag{A24}$$

H_{ref} is the zonal mean pressure scale height of the lower model and hence from Eq. (A24) and Reference A1 we have

$$h_1 = \sum_{n=1}^{9} \sum_{s=1}^{9} c_{ns} \xi^{s-1} Z_1^{n-1} , \qquad \xi = \sin \varphi \quad (\mathrm{km}^{-1}) \tag{A25}$$

$$h_2 = \sum_{n=1}^{9} \sum_{s=1}^{9} (n-1) c_{ns} \xi^{s-1} Z_1^{n-2}/Z_d \qquad (\mathrm{km}^{-2}) \tag{A26}$$

$$h_3 = \sum_{n=1}^{9} \sum_{s=1}^{9} (n-1)(n-2) c_{ns} \xi^{s-1} Z_1^{n-3}/Z_d^2 \; (\mathrm{km}^{-3}) \tag{A27}$$

where

$$Z_1 = (z_1 - Z_a)/Z_d, \quad Z_a = 48.75 \text{ km}, \quad Z_d = 31.25 \text{ km} \tag{A28}$$

and c_{ns} are linearly interpolated to the required date from the values tabulated in units of km^{-1} in Reference 1. The dependence of l_2, l_4, l_6 on longitude, λ, is expressed by q_r, which by Eq. (A2.3) and Eq. (A2.7) is

$$q_r = K_{1r} \cos \lambda + L_{1r} \sin \lambda + K_{2r} \cos 2\lambda + L_{2r} \sin 2\lambda \tag{A29}$$

where, for j = 1, 2; r = 1, 2, 3,

$$\begin{matrix} K_{jr} \\ \\ L_{jr} \end{matrix} = h_1^r Y_r , \qquad Y_r = (d^{r-1}y/dz^{r-1})_{z_1} \tag{A30}$$

$$y = R_1 T_j \begin{matrix}\cos \\ \sin\end{matrix} \lambda_{Tj}/10^3 M_{z_1 g_1} \quad (\mathrm{km}) . \tag{A31}$$

Values of y are calculated from the values of T_j, λ_{Tj} tabulated in Reference 1 for each month at 10° latitude steps and are linearly interpolated to the required date and latitude. Y_r are obtained numerically from values $y_{-1/2}$, $y_{1/2}$, $y_{3/2}$, $y_{5/2}$ of y at four equally-spaced heights $z_{-1/2}$, $z_{1/2}$, $z_{3/2}$, $z_{5/2}$ of which z_1 is the mid-point and Δz is the increment step by fitting a cubic to provide

$$Y_1 = (q\, a_+ - b_+)/16 \tag{A32}$$

$$Y_2 = (27\, a_- - b_-)/24\, \Delta z \tag{A33}$$

$$Y_3 = (b_+ - a_+)/2\, (\Delta z)^2 \tag{A34}$$

where

$$a_\pm = y_{3/2} \pm y_{1/2} \qquad b_\pm = y_{5/2} \pm y_{-1/2} \quad . \tag{A35}$$

For the tabulations in Reference A1, Δ_z = 4 km. For z_1 = 70 km (the value adopted), the four equally-spaced heights are 64, 68, 72, and 76 km. (For other values of z_1, Eq. (A32) to Eq. (A34) may need to be replaced by alternative formulas.) The dimensions of q_r are $(\mathrm{km})^{-2(r-1)}$ for r = 1, 2, 3.[A3]

The terms Δ_r relate to incremental changes of temperature in the vicinity of height z_1 that may be associated with the solar cycle. Corresponding to a change ΔR_n in sunspot number from a reference value R_{no}, we have the formulation (Appendix A2)

A3. Groves, G.V. (1986) An empirical model for solar cycle changes in mesospheric structure at longitudes 44 - 77° E, Planet. Space Sci. 34:1037-1041.

$$\Delta_r = -K(\phi)\,\Phi_r\,\Delta R_n \quad (r = 1, 2, 3) \tag{A36}$$

where

$$K(\phi) = p + q \cos^n \varphi \tag{A37}$$

and

$$\Phi_1 = (1 - \tau^2)(1 + \alpha\tau^3) \tag{A38}$$

$$\Phi_2 = \tau(1 - \tau^2)(-2 + 3\alpha\tau - 5\alpha\tau^3)/\ell \tag{A39}$$

$$\Phi_3 = 2(1 - \tau^2)[(1 - 3\tau^2) + \alpha\tau(3 - 16\tau^2 + 15\tau^4)]/\ell^2 \tag{A40}$$

where

$$\tau = \tanh[(z_1 - a)/\ell] \ . \tag{A41}$$

The quantities α, a, ℓ, p, q and n are calculated from

$$\theta = \theta_1 + f\,\theta_2 \quad (\theta = \alpha, \text{ a}, \ \ell, \text{ p}, \text{ q}, \text{ or n}) \tag{A42}$$

$$f = \tanh(4\phi/\pi) \cos[\pi(t_d - 1)/182.5] \tag{A43}$$

t_d being the day number in the year. Numerical values for θ_1, θ_2 ($\theta = \alpha$, a, ℓ, p, q or n) have been given[A3] but are tentative, being derived from limited data at eastern longitudes and therefore this dependence has only been included in exploratory calculations that are not a part of this report. The model of Reference A1 is for data over years of average sunspot number, $R_{no} = 65$.

For the conditions at height z_2, we have (Appendix A3)

$$\ell_3 = 10^3 M_{z_1} g_2(z_2)/R_2 T(z_2) \tag{A44}$$

where $T(z_2)$ is the temperature at height z_2 calculated from MSIS-86 as defined in Reference A2 for the required time, date, latitude, longitude, solar activity and so on. Also

$$\ell_5 = -(2d + u)\,\ell_3\, z_d \tag{A45}$$

$$\ell_7 = (6d^2 + 6\,ud + \eta)\,\ell_3\, z_d^2 \tag{A46}$$

where

$$d = (R_p + z_2)^{-1} \qquad (\mathrm{km}^{-1}) \;. \tag{A47}$$

For $z_2 \geqq z_a = 117.2$ km

$$u = -\sigma_g\,[1 - T_\infty / T(z_2)] \qquad (\mathrm{km}^{-1}) \tag{A48}$$

$$\eta = u(2u + \sigma_g) \qquad (\mathrm{km}^{-2}) \tag{A49}$$

$$\sigma_g = \sigma[g_2(z_2)/g_2(z_\ell)] \qquad (\mathrm{km}^{-1}) \tag{A50}$$

where σ is taken from MSIS-86, being related to the MSIS-86 parameters of temperature T_ℓ and temperature gradient T'_ℓ at $z_\ell = 120$ km and the MSIS-86 exospheric temperature T_∞ by $\sigma = T'_\ell/(T_\infty - T_\ell)$ as given in Reference A2.

For $z_2 \leqq z_a = 117.2$ km,

$$u = -2\,\chi_2\, T(z_2)(T_B + 2\,T_C\,\chi_2^2 + 3\,T_D\,\chi_2^4)\,(d\chi/dz)_{z_2} \tag{A51}$$

$$\eta = 2\,T(z_2)\,(T_B + 6\,T_C\,\chi_2^2 + 15\,T_D\,\chi_2^4)\,(d\chi/dz)_{z_2}^2 \tag{A52}$$

where

$$\chi_2 = -[\xi\,(z_2, z_a) - \xi\,(z_0, z_a)]/\xi\,(z_0, z_a) \tag{A53}$$

with

$$\xi\,(z, z_a) = (z - z_a)\,(R_r + z_a)/(R_r + z) \tag{A54}$$

and

$$\left(\frac{d\chi}{dz}\right)_{z_2} = - \frac{1}{\xi(z_0, z_a)} \frac{g(z_2)}{g(z_a)} . \qquad \text{(A55)}$$

The coefficients T_B, T_C, T_D are taken from MSIS-86 being related to the MSIS-86 parameters of temperature T_a and temperature gradient T_a' at $z = z_a$ and the MSIS-86 temperature T_o at height z_o of the MSIS-86 mesopause.[A2]

Finally, for the seventh condition, which involves values at both heights z_1 and z_2, we have (Appendix A4)

$$\ell_1 = (M_{z_1}/M_h)\, X/z_d \qquad (\mathrm{km}^{-1}) \qquad \text{(A56)}$$

where $M_h = 28$ kg/(kmol)$^{-1}$ and X is obtained by iteration (over only two or three cycles for 10^{-10} accuracy on taking an initial value of $X = (z_2 - z_1)/(7\ \mathrm{km})$ from Eq. (A4.9) written as

$$X = (M_h/\overline{M}_o \left[\ell n\ \mu_{N_2} - A_{N_2}^{-1}\ \ell n\ (1 + \nu_{N_2}^{A_{N_2}}\ e^{-X}) \right] \qquad \text{(A57)}$$

where $\overline{M}_o = 28.95$ kg(kmol)$^{-1}$ and

$$\mu_{N_2} = f_{N_2}\ p_1(z)/k(z_2)\ p_m(z_2, M_{N_2}); \qquad k(z_2) = 1.000292 \qquad \text{(A58)}$$

$$\nu_{N_2} = n_d(z_2, M_{N_2})/n_m(z_2, M_{N_2}) \qquad \text{(A59)}$$

$$A_{N_2} = M_h/(\overline{M}_o - M_{N_2}) \qquad \text{(A60)}$$

where $M_{N_2} = 28$ kg(kmol)$^{-1}$. f_{N_2} is the N_2 fractional volume of air at height z_1 (= 0.78084) and $p(z_1)$, the air pressure at height z_1, is

$$p(z_1) = p_{ref}(z_1)\ (1 + D_o)\ (1 + \Delta_o) \qquad \text{(A61)}$$

where $p_{ref}(z_1)$ is the zonal mean air pressure at height z_1 calculated from Reference A1

$$p_{ref}(z_1) = \exp\left(-31.25 \sum_{n=0}^{9} \sum_{s=1}^{9} c_{ns}\, \xi^{s-1}\, \zeta^n/_n\right) \quad \text{(mb)} \tag{A62}$$

($\zeta^n/_n$ denoting unity for n = 0). c_{ns} are linearly interpolated to the required date from the values tabulated in Reference A1. Dependence of $p(z_1)$ on longitude λ is introduced through

$$D_0 = K_{10} \cos \lambda + L_{10} \sin \lambda + K_{20} \cos 2\lambda + L_{20} \sin 2\lambda \tag{A63}$$

where, for j = 1, 2,

$$\begin{matrix} K_{j0} \\ L_{j0} \end{matrix} = (y)_{z_1} , \qquad y = p_j \begin{matrix} \cos \\ \sin \end{matrix} \lambda_{pj} . \tag{A64}$$

Values of y are calculated from the values of p_j, λ_{pj} tabulated in Reference A1 for each month and 10° latitude step and are linearly interpolated to the required date and latitude. The value of y at height z_1 is obtained by an interpolating cubic through four values $y_{-1/2}$, $y_{1/2}$, $y_{3/2}$, $y_{5/2}$ at heights $z_{-1/2}$, $z_{1/2}$, $z_{3/2}$, $z_{5/2}$ (as for Y_1 above), that is,

$$(y)_{z_1} = (9\, a_+ - b_+)/16 \tag{A65}$$

where

$$a_+ = y_{3/2} + y_{1/2} \qquad b_+ = y_{5/2} - y_{-1/2} . \tag{A66}$$

(For values of z_1 other than 70 km (the adopted value), Eq. (A66) may need to be replaced by an alternative formula.) Δ_0 is a relative pressure increase at height z_1 that may be associated with the solar cycle corresponding to Eq. (A36). We have[A3]

$$\Delta_0 = K(\phi)\, \ell\, \Phi_0\, \Delta R_n \tag{A67}$$

where

$$\Phi_0 = 1 + \tau + \frac{\alpha}{4} (\tau^4 - 1) . \tag{A68}$$

$n_d(z_2, M_{N_2})$, the N_2 diffusive profile number density, and $n_m(z_2, M_{N_2})$, the N_2 mixing profile number density, at height z_2 that appear in Eq. (A59) are MSIS-86 parameters that are calculated in units of cm^{-3} by the MSIS-86 formulation of Reference A2 for the required time, date, latitude, longitude, solar activity, and so on. In units of mb, we have

$$p_m(z_2, M_{N_2}) = 10^4 R_2 \mathcal{A}_{N2}^{-1} n_m(z_2, M_{N_2}) T(z_2) \qquad \text{(A69)}$$

where $T(z_2)$ is the MSIS-86 temperature at height z_2 for the required conditions and $\mathcal{A}_{N2}^{-1}$ is the reciprocal of Avogadro's number used in MSIS-86, that is,

$$\mathcal{A}_{N2}^{-1} = 1.66 \times 10^{-27} \quad \text{(kmol)} . \qquad \text{(A70)}$$

Hence $\mathcal{A}_{N2} = 6.02410 \times 10^{26}$ $(kmol)^{-1}$.

A2. DENSITY

At height z in the range (z_1, z_2) density ρ is calculated from

$$\rho = \sum_{i \neq 6} M_i n(z, M_i)/\mathcal{A}_N \quad (\text{kg m}^{-3}) \qquad \text{(A71)}$$

where $n(z, M_i)$ is the number density (m^{-3}) at height z of gas constituent of molecular weight M_i, the values of M_i being taken to be those of MSIS-86, that is, $M_1 = 4$, $M_2 = 16$, $M_3 = 28$, $M_4 = 32$, $M_5 = 40$, $M_7 = 1$ and $M_8 = 14$ corresponding to gases He, O, N_2, O_2, Ar, H and N. When different values of Avogadro's number are adopted for the lower and upper models, we take a smooth transition given by

$$\mathcal{A}_N = \frac{1}{2}[\mathcal{A}_{N1} + \mathcal{A}_{N2} + (\mathcal{A}_{N2} - \mathcal{A}_{N1}) \tanh c\zeta] \quad (-1 \leq \zeta \leq 1) \qquad \text{(A72)}$$

where

$$\mathcal{A}_{N1} = 6.02257 \times 10^{26} \quad \mathcal{A}_{N2} = 6.02410 \times 10^{26} \quad \text{(mks units)} \qquad \text{(A73)}$$

in the present calculation. For $n(z, M_i)$ we adopt the relations of the MSIS-86 formulation of Reference A2 and have (Appendix A5)

$$n(z_1, M_i) = 10^6 [n_d(z, M_i)^{A_i} + n_m(z, M_i)^{A_i}]^{A_i^{-1}} \; C_{1i}(z) C_{2i}(z) \quad (m^{-3}) \tag{A74}$$

$$A_i = M_h/(\overline{M}_o - M_i) \tag{A75}$$

$$n_d(z, M_i) = n_d(z_2, M_i)\, e^{M_i J(\zeta)} \, [T(z_2)/T(z)]^{(1+\alpha_i)} \tag{A76}$$

$$n_m(z, M_i) = n_m(z_2, M_i)\, e^{\overline{M}_o J(\zeta)} \; T(z_2)/T(z) \tag{A77}$$

$$J(\zeta) = [U(1) - U(\zeta)]\, z_d/M_{z_1} \tag{A78}$$

$$U(\zeta) = \sum_{s=1}^{7} \sum_{n=1}^{2} a_{sn}\phi_n(\zeta)\, \xi^{s-1} + b_1 \zeta + \frac{1}{2} b_2 \zeta^2 + \ldots + \frac{1}{7} b_7 \zeta^7 \tag{A79}$$

$$\phi_n(\zeta) = \zeta[\psi_1(\zeta, n) - \gamma_n \psi_2(\zeta)] \qquad (n = 1, 2) \tag{A80}$$

$$\psi_1(\zeta, n) = \zeta^n \left(\frac{1}{n+1} - \frac{3\zeta^2}{n+3} + \frac{3\zeta^4}{n+5} - \frac{\zeta^6}{n+7} \right) \tag{A81}$$

$$\psi_2(\zeta) = 1 - \zeta^2 + \frac{3}{5}\zeta^4 - \frac{1}{7}\zeta^6 \tag{A82}$$

where $\alpha_i = -0.4$ for i = 1 and 7 (He and H) and is otherwise zero. $C_{1i} = 1$ for N_2 (i = 3) and $C_{2i} = 1$ for He, N_2, O_2 and Ar (i = 1, 3, 4 and 5). For the remaining cases

$$C_{ji}(z) = \exp\left\{ r_{ji}/[1 + \exp(z - z_{ji})/H_{ji}] \right\} \qquad (j = 1, 2) \tag{A83}$$

$$r_{1i} = \frac{1}{2}\,[(R'_{1i} + R_{1i}) + (R_{1i} - R'_{1i}) \tanh\, c\zeta] \tag{A84}$$

$$r_{2i} = R_{2i} \tag{A85}$$

where

$$R_{1i} = \ell n\, [r_i\, n_m(z_\ell, M_{N_2})/n_m(z_\ell, M_i)] \; . \tag{A86}$$

The values of r_i, z_{ji}, H_{ji}, R_{2i} are those of MSIS-86 (Reference A2, Table 2d) and for i = 2, 7 and 8 (O, H and N)

$$R'_{1i} = R_{1i} \tag{A87}$$

whereas for i = 1, 4 and 5 (He, O_2 and Ar), R'_{1i} is chosen so that these constituents have been given volume fractions of air, f_i, at height z_1. The required values are given by (Appendix A5)

$$R'_{1i} = \left[\ell n \mu_i - A_i^{-1} \ell n \left\{ \left[\nu_i \, e^{/M_i J(-1)} \left(T(z_2)/T(z_1) \right)^{\alpha_i} \right]^{A_i} \left[e^{\overline{M}_o (J-1)} \right]^{A_i} \right\} \right] \left\{ 1 + \exp \left[(z_1 - z_{1i})/H_{1i} \right] \right\} \tag{A88}$$

$$p_m(z_2, M_i) = R_2 \, A^{-1}_{N2} \, n_m(z_2, M_i) \, T(z_2) \tag{A89}$$

$$\mu_i = f_i \, p(z_1)/\kappa(z_2) \, p_m(z_2, M_{N_2}) \tag{A90}$$

$$\nu_i = n_d(z_2, M_i)/n_m(z_2, M_i) \tag{A91}$$

for i = 1, 4 and 5, where we take

$$f_1(\equiv f_{He}) = 5.24 \times 10^{-6}, \quad f_4(\equiv f_{O_2}) = 0.21023, \quad f_s(\equiv f_{Ar}) = 9.34 \times 10^{-3}$$

$$\kappa(z_2) = \frac{8.31432 \times 6.02410}{6.02257 \times 8.314} = 1.000292 \; . \tag{A92}$$

In order to maintain continuity in the mean molecular weight at height z_1, the value taken for f_{0_2} is such that the mean molecular weight of air at height z_1 for the gas constituents N_2, O_2, Ar, He is equal to M_{z_1}, that is, such that $28 f_{N_2} + 32 f_{0_2} + 40 f_{Ar} + 4 f_{He} = M_{z_1}$ (= 28.9644). The value obtained, 0.21023, is slightly higher than the actual value, 0.20948, the excess being largely accounted for by the presence of CO_2 in the real atmosphere which is omitted in the model.

A useful check on computing accuracy is obtained by evaluating R'_{1i} for i = 3 (that is, N_2) and comparing its value with the adopted value of zero.

A3. PRESSURE

Total number density is obtained as

$$n = \sum_{n \neq 6} n(z, M_i) \qquad (m^{-3}) . \tag{A93}$$

Mean molecular weight is then

$$\overline{M} = \mathcal{A}_N \rho / n \qquad (kg\,(k\,mol)^{-1}) \tag{A94}$$

and pressure is

$$p = (R/\mathcal{A}_N)\, n\, T \qquad (N\, m^{-2}) . \tag{A95}$$

A4. TURBOPAUSE HEIGHT z_{hi} OF THE i th GAS CONSTITUENT

In the MSIS-86 formulation,[A2] turbopause height is taken to be the height z_{hi} at which

$$n_m(z_{hi}, M_i) = n_d(z_{hi}, M_i) \tag{A96}$$

and z_{hi} is a fixed parameter, being 105 km for N_2, O_2, Ar, N and O, 100 km for He and 95 km for H. In the present formulation, where MSIS-86 parameters are adopted for the height z_2 which (at 130 km) exceeds the heights z_{hi}, the MSIS-86 values for z_{hi} cannot hold unless the derived temperature profile in (z_{hi}, z_2) is the same as the MSIS-86 profile, which clearly is not the case. However, as deviations between the two profiles are not large, the values of z_{hi} satisfying Eq. (A96) would not be expected to differ greatly from the MSIS-86 values. In the computations that have been undertaken the differences have been less than 1 km.

We calculate

$$z_{hi} = z_a + z_d \zeta_{hi} \tag{A97}$$

where

$$\zeta_{hi} = \left\{ U(1) - \frac{z_d^{-1} M_{z_1}}{(M_o - M_i)} \ell n \left[\nu_i \left(\frac{T(z_2)}{T(z_1)} \right)^{\alpha_i} \right] \right\} \Big/ \left[U(\zeta_{hi})/\zeta_{hi} \right] . \qquad \text{(A98)}$$

The denominator in Eq. (A98) is calculated from

$$[U(\zeta)/\zeta] = \sum_{s=1}^{7} \sum_{n=1}^{2} a_{sn} \left[\psi_1(\zeta_i, n) - \gamma_n \psi_2(\zeta) \right] \xi^{s-1}$$

$$+ \; b_1 + \frac{1}{2} b_2 \zeta + \ldots + \frac{1}{7} b_7 \zeta^6 \; . \qquad \text{(A99)}$$

ζ_{hi} is obtained from Eq. (A98) by iteration with a suitable initial value (corresponding to say z_{hi} = 100 km).

Appendix A1

Formulation of W^{-1}

We define

$$W^{-1} = A + B \qquad (-1 \leqq \xi \leqq 1; \qquad -1 \leqq \zeta \leqq 1) \tag{A1.1}$$

where, for given S, N and a_{sn} (which are independent of ξ and ζ)

$$A = (1-\zeta^2)^3 \sum_{s=1}^{S} \sum_{n=1}^{N} a_{sn} (\zeta^n - \gamma_n) \xi^{s-1} \tag{A1.2}$$

$$B = \sum_{r=1}^{7} b_r \zeta^{r-1} \quad . \tag{A1.3}$$

γ_n are chosen so that for all values of ξ

$$\int_{-1}^{1} A \, d\zeta = 0 \quad . \tag{A1.4}$$

Hence

$$\gamma_n = G_n/G_o \tag{A1.5}$$

where

$$G_n = \int_{-1}^{1} (1 - \zeta^2)^3 \zeta^n \, d\zeta \; . \tag{A1.6}$$

On integrating by parts it may be shown that

$$(n+7)\, G_n = (n-1)\, G_{n-2} \tag{A1.7}$$

Hence for n even

$$\gamma_n = (G_n/G_{n-2}) \ldots (G_2/G_o)$$

$$= \frac{1.3 \; \ldots (n-3)\,(n-1)}{9.11 \ldots (n+5)\,(n+11)} \quad (\text{n even}) \; . \tag{A1.8}$$

For n odd, $G_1 = 0$ by direct evaluation and hence $G_3 = G_5 = \ldots = 0$ and

$$\gamma_n = 0 \quad (\text{n odd}) \; . \tag{A1.9}$$

b_r are chosen so that for given $\ell_1, \ldots, \ell_7$, by Eq. (A1.1) to Eq. (A1.4),

$$\int_{-1}^{1} B \, d\zeta = \int_{-1}^{1} W^{-1} \, d\zeta = \ell_1 \tag{A1.10}$$

$$B(-1) = W^{-1}(-1) = \ell_2, \; \frac{dB(-1)}{d\zeta} = \frac{dW^{-1}(-1)}{d\zeta} = \ell_4, \; \frac{d^2B(-1)}{d\zeta^2} = \frac{d^2W^{-1}(-1)}{d\zeta^2} = \ell_6 \tag{A1.11}$$

$$B(1) = W^{-1}(1) = \ell_3, \; \frac{dB(1)}{d\zeta} = \frac{dW^{-1}(1)}{d\zeta} = \ell_5, \; \frac{d^2B(1)}{d\zeta^2} = \frac{d^2W^{-1}(1)}{d\zeta^2} = \ell_7 \, . \tag{A1.12}$$

These conditions require that

$$\underline{S}^{-1} \, \underline{b} = \underline{\ell} \tag{A1.13}$$

where $\underline{b} = \left[b_1 \ldots b_7\right]'$, $\quad \underline{\ell} = \left[\ell_1 \ldots \ell_7\right]'$ and

$$\underline{S}^{-1} = \begin{bmatrix} 2 & 0 & \frac{2}{3} & 0 & \frac{2}{5} & 0 & \frac{2}{7} \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & -2 & 3 & -4 & 5 & -6 \\ 0 & 1 & 2 & 3 & 4 & 5 & 6 \\ 0 & 0 & 2 & -6 & 12 & -20 & 30 \\ 0 & 0 & 2 & 6 & 12 & 20 & 30 \end{bmatrix} \tag{A1.14}$$

From Eq. (A1.13), we obtain

$$\underline{b} = \underline{S}\,\underline{\ell} \tag{A1.15}$$

where, on inverting $\underline{S}^{-1}$

$$\underline{S} = \begin{bmatrix} 105 & -57 & -57 & -12 & 12 & -1 & 1 \\ 0 & -90 & 90 & -42 & -42 & -6 & 6 \\ -315 & 315 & 315 & 90 & -90 & 9 & 9 \\ 0 & 60 & -60 & 60 & 60 & 12 & -12 \\ 315 & -315 & -315 & -120 & 120 & -15 & -15 \\ 0 & -18 & 18 & -18 & -18 & -6 & 6 \\ -105 & 105 & 105 & 42 & -42 & 7 & 7 \end{bmatrix} \div 96 \tag{A1.16}$$

Appendix A 2

Conditions at Height z_1

By definition

$$W^{-1} = \frac{M_{z_1} g}{R\,T} = \frac{M_{z_1} g}{R\,T_{ref}} \frac{T_{ref}}{T(\lambda)} \tag{A2.1}$$

where the dependence of T on longitude λ is now indicated and T_{ref} denotes the zonal mean of $T(\lambda)$.

At height z_1, which is at or below 80 km, we have $R = R_1$, $g = g_1$ (as defined by Eqs. (A6) and (A7)) and from Reference B1, Appendix B.

$$H_{ref}^{-1} = M_{z_1} g_1 / R_1 T_{ref} = \sum_{n=1}^{9} \sum_{s=1}^{9} c_{ns}\, \xi^{\,s-1} Z^{n-1} \tag{A2.2}$$

$$\Delta T = T(\lambda) - T_{ref} = T_1 \cos(\lambda - \lambda_{T1}) + T_2 \cos(2\lambda - \lambda_{T2}) \tag{A2.3}$$

where ξ = sin (latitude), $Z = (Z - Z_a)/Z_d$, $Z_a = 48.75$ km, $Z_d = 31.25$ km and c_{ns}, T_1, T_2, λ_{T1}, λ_{T2} are tabulated in Reference B1. Hence from Eq. (A2.1) to Eq. (A2.3)

$$W^{-1} = h_1/D_1 \tag{A2.4}$$

$$d q_2/dz = (q_3 + 2 h_2 q_2)/k_1 \ . \tag{A2.14}$$

Hence Eq. (A2.12) to Eq. (A2.14) give, on using Eq. (A2.11)

$$d^2 W^{-1}/dz^2 = (D_1 D_3 + 2 D_2^2)/(h_1 D_1^3) \tag{A2.15}$$

where

$$D_3 = h_1 h_3 - 2 h_2^2 - q_3 \ . \tag{A2.16}$$

The required conditions at height z_1, which are expressed by Eq. (A1.11), become by Eqs. (A2.4), (A2.10), (A2.15) and (A5)

$$\ell_2 = h_1/D_1 + \Delta_1 \tag{A2.17}$$

$$\ell_4 = (D_2/D_1^2 + \Delta_2)\, z_d \tag{A2.18}$$

$$\ell_6 = \left[(D_1 D_3 + 2 D_2^2)/(h_1 D_1^3) + \Delta_3\right] z_d^2 \tag{A2.19}$$

where h_r, q_r and D_r are evaluated at $z = z_1$ and the terms

$$\Delta_r = \left[d^{r-1} (\Delta W^{-1})/dz^{r-1}\right]_{z_1} \tag{A2.20}$$

are introduced to enable an imposed change ΔW^{-1} of W^{-1} in the vicinity of $z = z_1$ to be taken into account due, for example, to a dependence on solar activity. Corresponding to an increase in temperature ΔT

$$\Delta W^{-1} = - W^{-1} T^{-1} \Delta T \ . \tag{A2.21}$$

A formulation has been given in Reference A3 for ΔT corresponding to a change in sunspot number ΔR_n, by which Eqs. (A2.20) and (A2.21) yield

$$d\,q_2/dz = (q_3 + 2\,h_2\,q_2)/k_1 \quad . \tag{A2.14}$$

Hence Eq. (A2.12) to Eq. (A2.14) give, on using Eq. (A2.11)

$$d^2\,W^{-1}/dz^2 = (D_1\,D_3 + 2\,D_2^2)/(h_1\,D_1^3) \tag{A2.15}$$

where

$$D_3 = h_1\,h_3 - 2\,h_2^2 - q_3 \quad . \tag{A2.16}$$

The required conditions at height z_1, which are expressed by Eq. (A1.11), become by Eqs. (A2.4), (A2.10), (A2.15) and (A5)

$$\ell_2 = h_1/D_1 + \Delta_1 \tag{A2.17}$$

$$\ell_4 = (D_2/D_1^2 + \Delta_2)\,z_d \tag{A2.18}$$

$$\ell_6 = \left[(D_1\,D_3 + 2\,D_2^2)/(h_1\,D_1^3) + \Delta_3\right] z_d^2 \tag{A2.19}$$

where h_r, q_r and D_r are evaluated at $z = z_1$ and the terms

$$\Delta_r = \left[d^{r-1}\,(\Delta W^{-1})/dz^{r-1}\right]_{z_1} \tag{A2.20}$$

are introduced to enable an imposed change ΔW^{-1} of W^{-1} in the vicinity of $z = z_1$ to be taken into account due, for example, to a dependence on solar activity. Corresponding to an increase in temperature ΔT

$$\Delta W^{-1} = -\,W^{-1}\,T^{-1}\,\Delta T \quad . \tag{A2.21}$$

A formulation has been given in Reference A3 for ΔT corresponding to a change in sunspot number ΔR_n, by which Eqs. (A2.20) and (A2.21) yield

$$\Delta_r = -K(\phi)\,\Phi_r\,\Delta R_n \tag{A2.22}$$

$$K(\phi) = p + q\cos^n\phi \tag{A2.23}$$

$$\Phi_r = \frac{d^{\,r-1}}{dz^{\,r-1}}\left[\frac{1+\alpha\ \tanh^3 Z_s}{\cosh^2 Z_s}\right]_{z=z_1} \tag{A2.24}$$

where

$$Z_s = (z-a)/\ell\ . \tag{A2.25}$$

The quantities α, a, ℓ, p, q and n are calculated from

$$\theta = \theta_1 + f\,\theta_2 \qquad (\theta = \alpha,\ a,\ \ell,\ p,\ q \text{ or } n) \tag{A2.26}$$

$$f = \tanh\,(4\phi/\pi)\cos\,[\pi(t_d - 1)/182.5] \tag{A2.27}$$

where t_d is the day number in the year and $\alpha_1 = 0.60$, $a_1 = 66.63$ km, $\ell_1 = 12.14$ km, $p_1 = 7.19 \times 10^{-5}$ km^{-1}, $q_1 = 4.80 \times 10^{-5}$ km^{-1}, $n_1 = 6.0$, $\alpha_2 = 0$, $a_2 = -3.09$ km, $\ell_2 = 0$, $p_2 = -0.51 \times 10^{-5}$ km^{-1}, $q_2 = -2.16 \times 10^{-5}$ km^{-1}, $n_2 = -5.0$.

Appendix A 3

Conditions at Height z_2

At height z_2 ($\geqq$ 90 km), MSIS-86 is valid and we have $R = R_2$, $g = g_2$ (as defined by Eq. (A.6) and Eq. (A.10)) and Eq. (A.1) becomes

$$W^{-1} = M_{z_1} g_2/R_2 T \; . \tag{A3.1}$$

By logarithmic differentiation

$$(W^{-1})^{-1} d(W^{-1})/dz = -2d - T^{-1} dT/dz \tag{A3.2}$$

where

$$d = 1/(R_p + z) \; . \tag{A3.3}$$

A further differentiation gives, by Eq. (A3.3),

$$(W^{-1})^{-1} \frac{d^2W^{-1}}{dz^2} - (W^{-1})^{-2} \left(\frac{dW^{-1}}{dz}\right)^2 = 2d^2 + \left(\frac{1}{T}\frac{dT}{dz}\right)^2 - \frac{1}{T}\frac{d^2T}{dz^2} \; . \tag{A3.4}$$

Hence from Eqs. (A3.2) and (A3.4)

$$(W^{-1})^{-1} \frac{d^2 W^{-1}}{dz^2} = 6d^2 + 4d \frac{1}{T}\frac{dT}{dz} + 2\left(\frac{1}{T}\frac{dT}{dz}\right)^2 - \frac{1}{T}\frac{d^2T}{dz^2} . \qquad \text{(A3.5)}$$

From Reference A2, different expressions hold for dT/dz, d^2T/dz^2 according to whether z is greater or less than $z_a = 117.2$ km.

For $z_2 \geqq z_a$, we have[A2]

$$T(z) = T_\infty - (T_\infty - T_\ell) \exp[-\sigma \xi (z, z_\ell)] \qquad \text{(A3.6)}$$

$$\xi (z, z_\ell) = (z - z_\ell)(R_p + z_\ell)/(R_p + z) \qquad \text{(A3.7)}$$

where T_∞ is exospheric temperature, T_ℓ is temperature at height z_ℓ (= 120 km) and $R_p = 6356.77$ km. σ is a constant that is related to the temperature gradient, T_ℓ', at $z = z_\ell$ by $\sigma = T_\ell'/(T_\infty - T_\ell)$. From Eq. (A3.6), we have

$$\frac{1}{T}\frac{dT}{dz} = -\sigma_g\left(1 - \frac{T_\infty}{T}\right) \qquad \text{(A3.8)}$$

$$\frac{1}{T}\frac{d^2T}{dz^2} = -\sigma_g\left(1 - \frac{T_\infty}{T}\right)\left[\frac{d}{dz}\left(\ell n \frac{d\xi}{dz}\right) - \sigma_g\right] \qquad \text{(A3.9)}$$

where

$$\sigma_g = \sigma \, d\xi/dz \qquad \text{(A3.10)}$$

and from Eq. (A3.7), by Eqs. (A10) and (A3.3),

$$d\xi/dz = (R_p + z_\ell)^2/(R_p + z)^2 = g_2(z)/G_2(z_\ell) \qquad \text{(A3.11)}$$

$$\frac{d}{dz}\left[\ell n \left(\frac{d\xi}{dz}\right)\right] = -2d . \qquad \text{(A3.12)}$$

Hence if

$$u = -\sigma_g (1 - T_\infty/T) \qquad \text{(A3.13)}$$

$$\eta = u(2u + \sigma_g) . \qquad \text{(A3.14)}$$

Equations (A3.2) and (A3.5) give by Eqs. (A3.8) to (A3.13)

$$(W^{-1})^{-1}\, d\, W^{-1}/dz = -\,(2d + u) \tag{A3.15}$$

$$(W^{-1})^{-1}\, d^2 W^{-1}/dz^2 = 6\,d^2 + 6\,u\,d + \eta \tag{A3.16}$$

where by Eqs. (A3.10) and (A3.11)

$$\sigma_g = \sigma\, g_2(z)/g_2(z_\ell) \ . \tag{A3.17}$$

For $z_2 \leqq z_a$, we have from Reference A2

$$T^{-1} = T_O^{-1} + T_B x^2 + T_C x^4 + T_D x^6 \tag{A3.18}$$

where

$$x = -\,[\xi\,(z, z_a) - \xi\,(z_o, z_a)]/\xi\,(z_o, z_a) \tag{A3.19}$$

$$\xi\,(z, z_a) = (z - z_a)\,(R_p + z_a)/(R_p + z) \ . \tag{A3.20}$$

z_o is mesopause height as determined by the MSIS-86 formulation. By Eq. (A3.18) we have

$$\frac{1}{T}\,\frac{dT}{dz} = -\,T\,\frac{dT^{-1}}{dz} = -\,2\,x\,T\,(T_B + 2\,T_C\,x^2 + 3\,T_D\,x^4)\,\frac{dx}{dz} \tag{A3.21}$$

$$2\left(\frac{1}{T}\,\frac{dT}{dz}\right)^2 - \frac{1}{T}\,\frac{d^2T}{dz^2} = T\,\frac{d^2T^{-1}}{dz^2} = 2\,x\,T\,(T_B + 2\,T_C\,x^2 + 3\,T_D x^4)\,\frac{dx}{dz}\,\frac{d}{dz}\left[\ell n\,\left(\frac{dx}{dz}\right)\right]$$
$$+\,2\,T\,(T_B + 6\,T_C\,x^2 + 15\,T_D\,x^4)\,\left(\frac{dx}{dz}\right)^2 \ . \tag{A3.22}$$

Equations (A3.2) and (A3.5) can then be written, by Eq. (A3.19) to Eq. (A3.22) and Eq. (A3.3), as Eq. (A3.15) and (A3.16), where

$$u = -2\,x\,T\,(T_B + 2\,T_C\,x^2 + 3\,T_D\,x^4)\,\frac{dx}{dz} \tag{A3.23}$$

$$\eta = 2\,T\,(T_B + 6\,T_C\,x^2 + 15\,T_D\,x^4)\,\left(\frac{dx}{dz}\right)^2 \tag{A3.24}$$

and by Eqs. (A3.19), (A3.20) and (A10)

$$\frac{dx}{dz} = -\frac{1}{\xi(z_o, z_a)} \frac{g_2(z)}{g_2(z_a)} . \tag{A3.25}$$

The required conditions at height z_2, which are expressed by Eq. (A1.12), become by Eqs. (A3.1), (A3.15) and (A3.16), on changing units from m to km in ℓ_3

$$\ell_3 = 10^3 M_{z_1} g_2(z_2)/R_2 T(z_2) \qquad (\mathrm{km}^{-1}) \tag{A3.26}$$

$$\ell_5 = -(2d + u)\, \ell_3\, z_d \qquad (\mathrm{km}^{-1}) \tag{A3.27}$$

$$\ell_7 = (6\, d^2 + 6\, ud + \eta)\, \ell_z\, z_d^2 \qquad (\mathrm{km}^{-1}) \tag{A3.28}$$

where d, u and η are evaluated at $z = z_2$.

Appendix A4

The N_2 Pressure Ratio Condition

We adopt the MSIS-86 representation of Reference A2 for the number density profile of a gas constituent, $n(z, M)$ as a meld of a diffusive profile $n_d(z, M)$ and a mixing profile $n_m(z, M)$. For molecular nitrogen, $M = M_{N_2}$ and the representation at $z = z_1$ is

$$n(z_1, M_{N_2})^{A_{N_2}} = n_d(z_1, M_{N_2})^{A_{N_2}} + n_m(z_1, M_{N_2})^{A_{N_2}} \tag{A4.1}$$

where

$$A_{N_2} = M_h/(\overline{M}_o - M_{N_2}) \tag{A4.2}$$

and $M_h = M_{N_2} = 28$, $\overline{M}_o = 28.95$ kg(kmol)$^{-1}$. On multiplying Eq. (A4.1) by $[(R_1/\mathcal{A}_{N1})\,T(z_1)]A_{N_2}$, where R_1 and $\mathcal{A}_{N1}$ are defined by Eqs. (A.6) and (A73), we obtain a relation in terms of the N_2 pressure $p(z_1, M_{N_2})$ at height z_1

$$p(z_1, M_{N_2})^{A_{N_2}} = p_d(z_1, M_{N_2})^{A_{N_2}} \div p_m(z_1, M_{N_2})^{A_{N_2}} \tag{A4.3}$$

where

$$p_d(z, M_i) = (R/\mathcal{A}_N)\, n_d(z, M_i)\ T(z) \tag{A4.4}$$

$$p_m(z, M_i) = (R/\mathcal{A}_N)\, n_m(z, M_i)\ T(z) \tag{A4.5}$$

with $M_i = M_{N_2}$.

By integration of the hydrostatic equation, the diffusive and mixing pressures are

$$K\, p_d(z, M_i) = p_d(z_1, M_i)\, e^{-M_i\, I(z_1,\, z)}\, [T(z_1)/T(z)]^{\alpha_i} \tag{A4.6}$$

$$K\, p_m(z, M_i) = p_m(z_1, M_i)\, e^{-\overline{M}_o\, I(z_1,\, z)} \tag{A4.7}$$

where

$$I(z_1, z) = \int_{z_1}^{z} (g/RT)\, dz$$

$$K \equiv k(z) = (R_1/\mathcal{A}_{N1})/[R(z)/\mathcal{A}_N(z)] \quad . \tag{A4.8}$$

On dividing Eq. (A4.3) by $\left[p_m(z_2, M_{N_2})\right]^{A_{N_2}}$ we obtain, using Eq. (A4.4) to Eq. (A4.7) with $M_i = M_{N_2}$, $\alpha_i = 0$

$$\mu_{N_2} = e^{(\overline{M}_o/M_h)X}\, (\nu_{N_2}^{A_{N_2}}\, e^{-X} + 1)^{A_{N_2}^{-1}} \tag{A4.9}$$

where

$$X = M_h\, I(z_1, z_2) \tag{A4.10}$$

$$\mu_{N_2} = f_{N_2}\, p(z_1)/K(z_2)\, p_m(z_2, M_{N_2}) \tag{A4.11}$$

$$\nu_{N_2} = n_d(z_2, M_{N_2})/n_m(z_2, M_{N_2}) \quad . \tag{A4.12}$$

f_{N_2} is the N_2 volume fraction of air at height z_1 and $p(z_1)$ is air pressure at height z_1, which is evaluated as

$$p(z_1) = p_{ref}(z_1)\,(1 + D_o)\,(1 + \Delta_o) \tag{A4.13}$$

where p_{ref} is the zonal mean value for a reference value of solar activity (sunspot number) and D_o, Δ_o are relative incremental increases associated with longitude and sunspot number respectively. We have

$$D_o = [p(\lambda) - p_{ref}]/p_{ref} = p_1 \cos(\lambda - \lambda_{p1}) + p_2 \cos(2\lambda - \lambda_{p2}) \tag{A4.14}$$

where p_1, p_2, λ_{p1}, λ_{p2} are tabulated in Reference A1. Corresponding to Eq. (A2.22), we have from Reference A3

$$\Delta_o = K(\phi)\,\ell\,\Phi_o \Delta R_n \tag{A4.15}$$

where

$$\Phi_o = [1 + \tanh Z_s + \frac{1}{4}\alpha\,(\tanh^4 Z_s - 1)]_{z=z_1} \quad . \tag{A4.16}$$

The required pressure ratio condition, which is expressed by Eq. (A1.10), is

$$\ell_1 = (M_{z_1}/M_h)\,X/z_d \tag{A4.17}$$

by Eqs. (A1), (A5), (A4.8) and (A4.10)

Appendix A5

Number Densities

For a gas constituent of molecular weight M_i, the MSIS-86 representation[A2] of number density $n(z, M_i)$ introduces factors $C_{1i}(z)$, $C_{2i}(z)$ to account for effects of chemistry and flow:

$$C_{ji}(z) = \exp\left\{r_{ji}/[1 + \exp(z - z_{ji})/H_{ji}]\right\} \qquad (j = 1, 2) \qquad \text{(A5. 1)}$$

$C_{1i} = 1$ for N_2 only ($i = 3$) and $C_{2i} = 1$ for all gases except O, H and N ($i = 2$, 7 and 8). The values adopted here for z_{ji}, H_{ji} ($j = 1, 2$) and r_{2i} are those presented in MSIS-86 for all gases. So also are the values adopted here for r_{1i} ($i = 2$, 7 and 8) as these gases (O, H and N) are not required to match significant volume fractions of air at height z_1 (= 70 km). The other gases (He, O_2 and Ar) are however required to match significant volume fractions f_i ($i = 1$, 4 and 5) at height z_1 and this is achieved by means of the relation

$$r_{1i} = \frac{1}{2}\left[(R'_{1i} + R_{1i}) + (R_{1i} - R'_{1i}) \tanh c\zeta\right] \qquad \text{(A5. 2)}$$

valid for $z_1 \leqq z \leqq z_2$, where c and ζ are defined by Eq. (A4) and Eq. (A5). R'_{1i} depends on f_i and is derived as shown below. Values of R'_{1i} computed in this way are found to lie within about one percent of R_{1i}. The adjustment using Eq. (A5. 2) to provide a smooth transition between lower and upper models (for He, O_2 and Ar concentrations) is therefore of negligible physical consequence.

For the calculation of $n(z, M_i)$ we have[A2]

$$n(z, M_i) = \left[n_d(z, M_i)^{A_i} + n_m(z, M_i)^{A_i} \right]^{A_i^{-1}} C_{1i}(z)\, C_{2i}(z) \qquad (cm^{-3}) \tag{A5.3}$$

$$A_i = M_h / (\overline{M}_o - M_i) \tag{A5.4}$$

$$n_d(z, M_i) = n_d(z_2, M_i)\, e^{M_i J(\zeta)} \left[T(z_2)/T(z) \right]^{1+\alpha_i} \qquad (cm^{-3}) \tag{A5.5}$$

$$n_m(z, M_i) = n_m(z_2, M_i)^{\overline{M}_o J(\zeta)}\; T(z_2)/T(z) \qquad (cm^{-3}) \tag{A5.6}$$

where α_i is the thermal diffusion coefficient and by Eqs. (A4.8), (A1) and (A5)

$$J(\zeta) \equiv I(z, z_2) = [U(1) - U(\zeta)]\, z_d / M_{z_1} \tag{A5.7}$$

where

$$U(\zeta) = \int^{\zeta} W^{-1}\, d\zeta \, . \tag{A5.8}$$

By Eq. (A1.1) to Eq. (A1.3)

$$U(\zeta) = \sum_{s=1}^{S} \sum_{n=1}^{N} a_{sn}\, \varphi_n(\zeta)\, \xi^{s-1} + b_1 \zeta + \frac{1}{2} b_2 \zeta^2 + \ldots + \frac{1}{7} b_7 \zeta^7 \tag{A5.9}$$

$$\varphi_n(\zeta) = \int^{\zeta} (1 - \zeta^2)^3 (\zeta^n - \gamma_n)\, d\zeta = \zeta \left[\psi_1(J, n) - \gamma_n \psi_2(\zeta) \right] \tag{A5.10}$$

$$\psi_1(\zeta, n) = \zeta^n \left[\frac{1}{n+1} - \frac{3\zeta^2}{n+3} + \frac{3\zeta^4}{n+4} - \frac{\zeta^6}{n+7} \right] \tag{A5.11}$$

$$\psi_2(\zeta) = 1 - \zeta^2 + \frac{3}{5} \zeta^4 - \frac{1}{7} \zeta^6 \, . \tag{A5.12}$$

To evaluate R'_{1i} ($i = 1, 4,$ or 5) we note that $C_{2i} = 1$ ($i = 1, 4$ or 5) and put $z = z_1$ in Eq. (A5.3) to obtain, on multiplying through by $(R_1 / A_{N1}) T(z_1) / p_m(z_2, M_i)$ and using Eq. (A4.4) to Eq. (A4.7) and Eq. (A5.7),

$$\mu_i = \left\{ \left[\nu_i \, e^{M_i J(-1)} \left(\frac{T(z_2)}{T(z_1)} \right)^{\alpha_1} \right]^{A_i} + \left[e^{\overline{M}_o J(-1)} \right]^{A_i} \right\}^{A_i^{-1}} C_{1i}(z_1) \qquad \text{(A5. 13)}$$

where

$$\mu_i = f_i \, p(z_1)/\kappa(z_2) \, p_m(z_2, M_i) \qquad \text{(A5. 14)}$$

$$\nu_i = n_d(z_2, M_i)/n_m(z_2, M_i) \ . \qquad \text{(A5. 15)}$$

By Eqs. (A5. 1) and (A5. 13), we may solve for r_{1i} $(= R'_{1i})$, where

$$R'_{1i} = \left\{ 1 + \exp\left[(z_1 - z_{1i})/H_{1i}\right] \right\} \ell n \, C_{1i}(z_1) \qquad \text{(A5. 16)}$$

and

$$\ell n \, C_{1i}(z_1) = \ell n \, \mu_i - A_i^{-1} \ell n \left\{ \left[\nu_i \, e^{M_i J(-1)} \left(\frac{T(z_2)}{T(z_1)} \right)^{\alpha_i} \right]^{A_i} + \left[e^{\overline{M}_o J(-1)} \right]^{A_i} \right\} .$$

(A5. 17)

Appendix B

Method of Determination of a_{sn}

We write Eq. (A1.2) as

$$\sum_{s=1}^{S} \sum_{n=1}^{N} C(s, n)\, a_{sn} = A \tag{B1}$$

where

$$C(s, n) = (1 - \zeta^2)^3 (\zeta^n - \gamma_n)\, \xi^{s-1} \tag{B2}$$

and determine a_{sn} by the method of weighted least-squares from sets of values $C_k(s, n)$ ($s = 1, \ldots, S$; $n = 1, \ldots, N$), A_k for $k = 1, \ldots, K$. The weighting is based on estimated standard deviations of A_k, σA_k, which are obtained as described below.

The K sets of values are taken at grid points located on a meridional cross-section at each 5 km height interval from z_1 to z_2 (excluding the end points where $\zeta = \pm 1$ and no contribution is made to the determination of a_{sn}) and at each 10° latitude from pole to pole. Then

$$K = 19\,[(z_2 - z_1)/5 - 1] \,. \tag{B3}$$

Likewise $\overline{F}_{10.7}$ is obtained from the three-monthly sunspot number. A_p may be specified for any launch or otherwise set equal to 10. Few profiles extend above 100 km at high latitudes (see Table 3) where dependence on A_p may be important. After examining A_p values for a sample of such launches, the approximation A_p = 10 for all launches appeared to be justified.

Dependence on local solar time in the upper model is included, when known, as in the case of single temperature profiles. For monthly mean temperature data, B is calculated from Eq. (A14), that is, Eq. (A1.3), for the diurnal mean upper model with the exception of incoherent scatter data which are obtained during daytime hours only. For I. S. data, B is evaluated for each hour between 0800 and 1600 hours and the average is taken of these 11 values.

The weighted average of the values of A calculated from Eq. (B4) for the k th grid point is based on those temperatures at the height of the k th grid point that lie within 15° latitude of the k th grid point and whose date of observation lies within 1.5 months of the middle of the given month. The weighting factor used in the averaging process is

$$\exp\left\{-\frac{1}{2}\left[(\Delta\phi/10)^2 + \Delta^2 m\right]\right\} \tag{B7}$$

where $\Delta\phi$ is the latitude displacement from the grid point (in degrees) and Δm is the data displacement (in months), $\Delta\phi/10$, Δm being less than 1.5. The most extreme data point to be included in the average is therefore at $\Delta\phi = 15°$, $\Delta m = 1.5$ and has a weight of $e^{-2.25}$ (= 0.11) compared with a data point at the grid point ($\Delta\phi$ = m = 0) for which the weight is unity.

Temperature data are available either as single observations or as monthly mean values, but the relative accuracies of the various types of data are invariably unknown. The final determination of a_{sn} are not however, sensitive to these relative accuracies as data for single profiles and monthly means are from different locations and tend not to combine.

The introduction of the weighting factor Eq. (B7) results in fractional values for the weighted number of observations, N_w, and the minimum value for N_w below which the available temperature data are considered insufficient for the determination of A_k is taken to be 1.1 In that case A_k is taken to be the value of A_k for the same latitude in the opposite hemisphere with the month shifted by six months, if such a determination is possible with the data available. By this procedure, it was found that A_k could be determined at all grid points except for a number at high latitude (60° or more) and above 100 km. For these grid points A_k is determined from Eq. (B4) with T equal to its MSIS-86 value.

Likewise $\overline{F}_{10.7}$ is obtained from the three-monthly sunspot number. A_p may be specified for any launch or otherwise set equal to 10. Few profiles extend above 100 km at high latitudes (see Table 3) where dependence on A_p may be important. After examining A_p values for a sample of such launches, the approximation $A_p = 10$ for all launches appeared to be justified.

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$$\exp\left\{-\frac{1}{2}\left[(\Delta\phi/10)^2 + \Delta^2 m\right]\right\} \tag{B7}$$

where $\Delta\phi$ is the latitude displacement from the grid point (in degrees) and Δm is the data displacement (in months), $\Delta\phi/10$, Δm being less than 1.5. The most extreme data point to be included in the average is therefore at $\Delta\phi = 15°$, $\Delta m = 1.5$ and has a weight of $e^{-2.25}$ (= 0.11) compared with a data point at the grid point ($\Delta\phi = m = 0$) for which the weight is unity.

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At the k th grid point, σA_k, the standard deviation of the weighted average A_k, is estimated from the standard deviation, σ, of the distribution of values of A in the average. The relation adopted is

$$\sigma A_k = \sigma/(N_w - 1.1)^{1/2} \tag{B8}$$

in which σ is also an estimated value. In those cases where A_k is found from MSIS-86 temperatures, σA_k is calculated as

$$\sigma A \equiv \sigma\,(M_{z_1} g/RT) = (M_{z_1} g/RT_c)(\sigma T/T_c) \tag{B9}$$

where T_c is the temperature value from CIRA 1972, Part 1 and

$$\log_{10}(\sigma T) = a\,(z - 67.5)/42.5 + b \tag{B10}$$

where a = 0.519, b = 0.617, (being values based on CIRA 1972 temperature distributions.[B1] Equation (B10) gives σT = 4.4, 10.3, 24.0 K at 70, 100, 130 km, respectively.

In those cases where σA_k can be found from Eq. (B7), it was desirable to avoid unreasonably small values of σA_k, which may arise at times with selective distributions of data. Hence σA_k is compared with σA and if found to be less than $\sigma A/3$, we take $\sigma A_k = \sigma A$.

The procedure for determining S and N in Eq. (B1) is to take them as small as possible and consistent with a satisfactory least-squares fit to the values of A_k. The values chosen are S = 7, N = 2.

Sets of values of a_{sn} determined for each month for Case 1 of Section 4.1 are listed in Table B1 and relate to the middle of the month.

B1. COSPAR Working Group 4, (1972) COSPAR International Reference Atmosphere, CIRA 1972, Akademie Verlag, Berlin.

Table B1. Coefficients a_{sn} Calculated for Case 1

JANUARY							
A11...A71 =	0.301202E+01	-0.251538E+01	-0.443331E+01	0.188192E+02	0.203840E+02	-0.129029E+02	-0.228502E+02
A12...A72 =	-0.715264E+01	-0.108063E-01	-0.870311E+01	-0.770329E+01	0.827469E+02	0.116319E+02	-0.744077E+02
FEBRUARY							
A11...A71 =	0.426859E+01	-0.959048E+00	-0.261623E+02	0.130303E+02	0.640788E+02	-0.105092E+02	-0.453879E+02
A12...A72 =	-0.196444E+01	0.108858E+02	-0.467195E+02	-0.418177E+02	0.147475E+03	0.310107E+02	-0.108580E+03
MARCH							
A11...A71 =	0.361242E+01	0.719224E-01	-0.238752E+02	0.546735E+01	0.590269E+02	-0.532137E+01	-0.422811E+02
A12...A72 =	-0.100139E+01	0.158461E+02	-0.640373E+02	-0.256613E+02	0.205269E+03	0.757655E+01	-0.152434E+03
APRIL							
A11...A71 =	0.525444E+01	0.666923E+01	-0.279852E+02	-0.202152E+02	0.560154E+02	0.118667E+02	-0.372689E+02
A12...A72 =	-0.113747E+00	0.256542E+02	-0.441529E+02	-0.567535E+02	0.116691E+03	0.292495E+02	-0.827923E+02
MAY							
A11...A71 =	0.597164E+01	0.397463E+01	-0.266255E+02	-0.206933E+02	0.541631E+02	0.135430E+02	-0.369944E+02
A12...A72 =	-0.654689E+00	0.267372E+02	-0.521902E+02	-0.664613E+02	0.161207E+03	0.374091E+02	-0.115736E+03
JUNE							
A11...A71 =	0.493858E+01	0.790258E+00	-0.153545E+02	-0.104536E+02	0.337583E+02	0.483341E+01	-0.280535E+02
A12...A72 =	-0.345034E+01	0.140357E+02	-0.375787E+02	-0.169333E+02	0.131929E+03	-0.267727E+01	-0.992142E+02
JULY							
A11...A71 =	0.367153E+01	0.332649E+01	-0.114253E+02	-0.212884E+02	0.365558E+02	0.145437E+02	-0.326129E+02
A12...A72 =	-0.471524E+01	-0.103331E+01	-0.308120E+02	0.147489E+02	0.124142E+03	-0.186682E+02	-0.964741E+02
AUGUST							
A11...A71 =	0.522057E+01	0.121652E+01	-0.264839E+02	-0.906353E+01	0.622827E+02	0.555833E+01	-0.439554E+02
A12...A72 =	-0.217957E+00	-0.612739E+01	-0.704407E+02	0.284454E+02	0.201276E+03	-0.228810E+02	-0.140784E+03
SEPTEMBER							
A11...A71 =	0.463176E+01	0.225654E+00	-0.210797E+02	-0.575018E+01	0.478414E+02	0.532087E+01	-0.346165E+02
A12...A72 =	0.548458E+00	-0.457695E+01	-0.911955E+02	0.191963E+00	0.265280E+03	0.656328E+01	-0.187074E+03
OCTOBER							
A11...A71 =	0.473461E+01	-0.678040E+01	-0.157533E+02	0.212122E+02	0.271358E+02	-0.125962E+02	-0.195211E+02
A12...A72 =	0.101777E+01	-0.151417E+02	-0.668751E+02	0.315387E+02	0.168782E+03	-0.145833E+02	-0.113652E+03
NOVEMBER							
A11...A71 =	0.401070E+01	-0.684372E+01	-0.331910E+01	0.287240E+02	0.431566E+01	-0.185412E+02	-0.791273E+01
A12...A72 =	0.827888E+00	-0.122259E+02	-0.762859E+02	0.268201E+02	0.219777E+03	-0.130161E+02	-0.150610E+03
DECEMBER							
A11...A71 =	0.283359E+01	-0.753740E+00	0.531743E+01	0.127062E+02	-0.105800E+02	-0.716067E+01	-0.195789E+01
A12...A72 =	-0.520754E+01	-0.751404E+01	-0.223551E+02	-0.544138E+01	0.109860E+03	0.173846E+02	-0.894572E+02

Appendix C

Average Temperature Deviations from Model Values and Their Mean with Respect to Different Sizes

Comparisons between observed temperatures, T, and model values T_m are analyzed in terms of the differences

$$T_d = T - T_m \tag{C1}$$

at each 5 km height interval. For the i th site we obtain the average deviation at any height as

$$x_i = \sum T_d / N_b \tag{C2}$$

where N_b is the number of observations available within a selected group of months. Four such groups are considered, namely (a) the three 'winter' months (DJF in the N hemisphere); (b) the six 'equinox' months (MAMSON); (c) the three 'summer' months (JJA in the N hemisphere); and (d) all months. The standard deviation of x_i was estimated in each case as

$$\sigma_{x_i} = \left[\sum (T_d - x_i)^2 / N_b (N_b - 1) \right]^{1/2} \tag{C3}$$

for $N_b \geqq 2$.

The mean of x_i with respect to those sites for which a value of x_i could be determined was obtained as

$$\overline{x} = \sum_i w_i \, x_i / N_s \tag{C4}$$

where

$$w_i = N_s (\sigma_{x_i})^{-2} / \sum_i (\sigma_{x_i})^{-2} \tag{C5}$$

and N_s is the number of such sites.

The standard deviation of $\overline{x}$ was estimated as

$$\sigma_{\overline{x}} = \sigma_D / (N_s - 2)^{1/2} \tag{C6}$$

where σ_D is the standard deviation of the distribution of the values, x_i, about $\overline{x}$, being estimated (for $N_s > 2$) from

$$\sigma_D^2 = \sum_i w_i (x_i - \overline{x})^2 / (N_s - 1) \ . \tag{C7}$$

Appendix D

Coding of the Model Formulation

In the course of this project Fortran programs have been written and tested for each stage of the model formulation and the work has proceeded to completion with the confidence that the formulation was computationally practical and efficient.

Over 50 programs have been developed, some of which are subprograms to the main calculation while others have served only a transient purpose. The latter category includes test programs (that is, main programs for temporary use in the development and testing of the subprograms) and programs for one-of calculations such as the inversion of matrix Eq. (A1.14) and the calculation of Millstone Hill and St. Santin I.S. temperatures from formulas in the references quoted in this report.

The main programs will be described briefly in this Appendix to indicate some of the chief computational stages of the work. Details of the subprograms and input files that are utilized in conjunction with these main programs are given in Appendix E. The particular way in which the computation breaks down into different subprograms reflects the stage-by-stage development of the method. No retrospective consideration has been given at the present time into restructuring the coding. Computational efficiency nevertheless appears to be quite good. All computations have been carried out interactively on EUCLID (the GEC machine at University College London).

D1. DETERMINATION OF a_{sn} (APPENDIX B)

TDIFAVP4 (Temperature Differences Averaged Program 4) calculates A from Eq. (B4) for each observed temperature at 5-km intervals and takes weighted averages to obtain A_k at each grid point of the height-latitudinal cross-section. σA_k is calculated by Eq. (B8). When temperature data are lacking A_k is calculated from Eq. (B4) for heights above 90 km using the temperature value of MSIS-86 and σA_k is used as a flag and set equal to zero.

(Note: the subprograms listed below need to be added to the main program in all cases. Subprograms that are already contained in a main program are not listed, being usually just short routines.)

Subprograms: POLYZ12S, BCZ12S, BCATZ1S, BCATZ2S, EARTHS, GTS5S, MSISINS, SCATZ1S.

Input Files: TWP12Q, COEFFDQ, RZDATA, THADATA, POLYTDD, DUMMYAXD.

Output Files: TDIF(N_1), TDIF(N_1)Q, TD(N_1)SD.

(N_1) stands for an integer (the run number and is used to identify the outputs corresponding to different inputs). TDIF(N_1) contains A_k and σA_k; TDIF(N_1)Q is an inspection file for output from the various stages of the computation; and TD(N_1)SD contains the average temperature deviations from the fitted profile, x_i, and their standard deviations, σx_i, for the i th site at each 5-km height interval, the average being taken four times with respect to data falling in each of the groups of months (i) DJF, (ii) MAMSON, (iii) JJA and (iv) all months.

WADJP6 (W^{-1} Adjustment Program 6) obtains a_{sn} by weighted least-squares solution of Eq. (B1) for each month of the year. Before doing this, it processes A_k and σA_k for each grid point of the height-latitudinal cross-section as described in Appendix B: (1) if A_k, σA_k have been calculated from observed temperature data they remain unchanged; (2) if $\sigma A_k = 0$ (that is, data are lacking), A_k, σA_k are taken as the values for the grid point at the same latitude in the opposite hemisphere with a six-month shift of date, unless this also has $\sigma A_k = 0$ (that is, data are lacking there as well) when, at the original grid point, A_k is left unchanged (having been based on an MSIS-86 temperature) and σA_k is set equal to σA, the value calculated from Eq. (B9); and (3) any σA_k which is less than $\sigma A/3$

is considered improbably small and is replaced by σA.

WADJP6 is for Case 1 of Section 4. 1

Subprogram: NAG library routine F04ARF.

Input File: TDIF(N_1)

Output Files: OUTRN(N_1), WADJ(N_1)D.

OUTRN(N_1) is an inspection file and WADJ(N_1)D contains a_{sn}.

WADJP7 is WADJP6 modified to deal with Cases 2 and 3 of Sections 4.2 and 4. 3.

D2. COMPARISON OF OBSERVATIONS WITH DERIVED MODEL

TDIFAVP4 re-run. TDIFAVP4 is run as above with the following changes:

Input Files: as before with DUMMYAXD replaced by WADJ(N_1)D.

Output Files: TDIF(N_2), TDIF(N_2)Q, TD(N_2)SD.

Observed temperature data are now compared with the final model, calculated from Eqs. (A1), (A12) and (A13) using the determinations of a_{sn} which are read in from WADJ(N_1)D, whereas in the first use of TDIFAVP4 above a_{sn} were unknown and were read in as zeroes from DUMMYAXD. The purpose of this computation is to obtain TD(N_2)SD for x_i, σx_i for use with AVTDSDP8.

AVTDSDP8 (Average of mean Temperature Deviations and its Standard Deviation Program 8). For each site, the mean temperature deviations x_i from the model with respect to data taken in each of four groups of months, namely DJF, MAMSON, JJA and all year, and estimates of their standard deviations σx_i are read from TD(N_2)SD. The sites are put into three latitude groups, 0-30, 30-50, and 50-90° N or S and their summer, equinox, winter and all-year mean deviations are averaged and the standard deviations of these averages are obtained from Eqs. (C4) to (C7). Results are shown in Tables 4 through 10 for the all-year mean deviations.

Subprograms: none

Input File: TD(N_2)SD.

Output File: AV(N_2)Q.

D3. TABULATION OF ATMOSPHERIC PROPERTIES AT HEIGHTS ABOVE 18 km

TVALP (Temperature Value Program) was written to develop a method for combining the outputs of the three models for the regions 18 to 70, 70 to 130, and above 130 km for given ranges of geophysical parameters (height, date, location, solar activity and so on). The program was first written for temperature only and later extended to provide composition, density and pressure. Five subprograms are included in this main program which generate particular outputs when flagged to do so:

TPDN	for generating output of the height profiles of temperature and $\log_{10}$ of pressure, density and total number density at given height increments and their third differences with respect to height (to enable the smoothness of these profiles to be examined at 70 and 130 km where continuity in the second height-derivative has been formulated).
CHPARM	for generating output of MSIS-86 diffusion and mixing number densities at 130 km, that is, $n_d(z_2, M_i)$ and $n_m(z_2, M_i)$; MSIS-86 density parameter R_{1i} and the amended value R'_{1i} [Eq. (A5.15)]; and turbopause height z_{hi} [Eq. (A96)].
CHNUMD	for generating output of $\log_{10}$ of the number density of gas constituents, $n(z, M_i)$ at given height increments and their third differences with respect to height (to enable the smoothness of these profiles to be examined at 70 and 130 km where continuity in the second height-derivative has been formulated).
ATMOS	for generating output of temperature and of $\log_{10}$ of pressure, density, total number density and individual gas number densities.
ATMOSN	for generating output of temperature, number density, total number, pressure and density.
<u>Subprograms</u>:	TEMPS, POLYZ12S, BCZ12S, BCATZZS, BCATZ2S, SCATZ1S, EARTHS, MSISINS, LINES, GTS5S, CF1880S, CFZ1Z2S.

Input Files: TWP12Q, COEFFDQ, WADJ(N_1)D, PARAMD.

Output File: TABLEQ.

TVAL1KMP (TVALP amended to give 1 km interval table Program). TPDN and CHNUMD are deleted from TVALP and changes are introduced in conjunction with three subprograms that are added:

TPDTB1 for generating output of separate tables of temperature, pressure, density and geostrophic W-E wind on each page of output with the same format and an integer height interval (say 1 km) as in the corresponding tables in the report 'A Global Reference Atmosphere From 18 to 80 km'.[A1]

POWER for use with TPDTB1 to calculate the power of 10 needed in the pressure and density tables.

GEOW for use with TPDTB1 to calculate geostrophic W-E wind velocities.

Subprograms and Input Files: as TVAL (but PRM86D1 replaces PARAMD).

Output File: TAB86Q1.

TAVL5KMP (TAVLP amended to give 5 km interval table Program). TVAL1KMP has subprogram TPDTB1 replaced by TPDTB5 and a few associated changes:

TPDTB5 for generating tables of temperature, pressure, density and geostrophic wind with an integer height interval (say 5 km) for each of four selected months such that these 12 tables fit into one page of output as shown in Appendix F. Six tables for just two months appear on one page if the number of heights tabulated exceeds a specified number.

Subprograms and Input Files: as TVAL (but PRM86D5 replaces PARAMD).

Output File: TAB86Q5

Appendix E

Memo List of Subprograms and Input Datafiles

COEFFDQ (Coefficients from part D of an earlier Q (standing for output)) is a datafile containing the coefficients c_{ns} for the lower model (Reference A1, pp. 108-109).

TPW12Q (Temperature, Pressure Waves 1 and 2 from an earlier Q) is a datafile containing the tables of amplitudes and phases of Reference A1, pp. 110-121, which define the longitudinal dependences of temperature, pressure and density for the lower model. (Only the temperature and pressure dependences are utilized.)

BCATZ1S (Boundary Conditions at height z_1 Subprogram) is

SUBROUTINE BCATZ1(ZZ, DAY, MN, GLAT, GLONG, G)

which is used with TDIFAVP4 (Appendix D) and interpolates coefficients c_{ns} of the 18 to 80 km region to the given day, DAY, of month, MN, and calculates the required conditions at latitude, GLAT, and height, ZZ (= z_1 = 70 km) transferring these values back to the calling program as G(1), ... G(4) = $p(z_1, M_{N_2})$, $100\ W^{-1}$ and the first two derivatives of $100\ W^{-1}$ with respect to height at height z_1 according to the relations in Appendix A2. Longitude (GLONG) dependence is included unless ILONG1 is set equal to zero in the main program.

BCATZZS (Boundary Conditions at height z_1 or at lower height z Subprogram) is

SUBROUTINE BCATZZ(ZZ, DAY, MN, GLAT, GLONG, G)

which is used with TVALP, TVAL1KMP, TVAL5KMP (Appendix D) and is BCATZ1S(ZZ, DAY, MN, GLAT, GLONG, G) with an additional section of instructions such that when ZZ = 70 (km) it provides the same G(1), ... G(4) as BCATZ1S and for other ZZ (= z) it provides $G(1) = p(z, M_{N_2})$ and $G(2) = 100\ W^{-1}$ at height z (less than 70 km).

GTS5S is the MSIS-86/CIRA 1986 neutral atmosphere model of 15 March 1986 by A.E. Hedin as

SUBROUTINE GTS5(IYD, SEC, ALT, GLAT, GLONG, STL,
F107A, F107, AP, MASS, D, T)

with the additional facility to transfer parameters to other programs through the common block AA defined by

COMMON/AA/ DDF(8), DMX(8), HC04, HC16, BLK1, HC32,
HC40, BLK2, HC01, HC14, ZC04, ZC16,
BLK3, ZC32, ZC40, BLK4, ZC01, ZC14,
BLK5, RC16, BLK6, BLK7, BLK8, BLK9,
RC01, RC14, BLK10, HCC16, BLK11, BLK12,
BLK13, BLK14, HCC01, HCC14, BLK15,
ZCC16, BLK16, BLK17, BLK18, BLK19,
ZCC01, ZCC14, RCU(8)

where DDF(I), DMX(I) are respectively the diffusion profile number density $n_d(z, M_I)$ and the mixing profile number density $n_m(z, M_I)$ corresponding to I= 1, 2, 3, 4, 5, 7, 8. RCU(I) are likewise the values of R_{1i} (Appendix A5).

BCATZ2S (Boundary Conditions at height z_2 Subprogram) is

SUBROUTINE BCATZ2(IYD, SEC, Z2, GLAT, GLONG, STL,
F107A, F107, AP, G)

which calls GTS5 to calculate the MSIS-86 conditions required at height z_2 (= 130 km) and transfer them to the calling program as G(1), ... G(6) = $p_m(z_2, M_{N_2})$, $p_d(z_2, M_{N_2})$, $100W^{-1}$ and the first three derivatives of $100\ W^{-1}$ with respect to height at height z_2 according to the relations in Appendix A3. (G(6) is not utilized.)

BCZ12S — (Boundary Conditions at z_1 and z_2 Subprogram) is

SUBROUTINE BCZ12(Z1,Z2,IDAY,MN,GLAT,GLONG,
SLT,F107A,F107,AP,G1,G2)

and is the calling program of (1) either BCATZ1 (if used with TDIFAVP4) or BCATZZ (if used with TVALP, TVAL1KMP or TVAL5KMP) to obtain G(I) as G1(I) to which the sunspot number dependent changes are applied by calling SCATZ1 and (2) BCATZ2 to obtain G(I) as G2(I).

SCATZ1S — (Solar Cycle at height z_1 Subprogram) is

SUBROUTINE SCATZ1(ZZ, IYD, GLAT, RNDEL, GDEL)

which calculates incremental values GDEL(I) arising from an incremental change of sunspot number RNDEL according to the relations Eqs. (A2. 22) and (A4. 15).

RZDATA — (Sunspot number, R_z, Datafile) contains monthly mean sunspot numbers from January 1957 to January 1972, the interval of time within which the launch dates of single rocket profiles fail.

POLYZ12S — (Polynomial coefficients for height range z_1 to z_2 Subprogram) is

SUBROUTINE POLYZ12(Z1,Z2,IDAY,MN,GLAT,GLONG,
SLT,F107A,F107,AP,B)

which calculates the polynomial coefficients $\underline{b}$ from Eq. (A1. 15) having first obtained $\underline{\ell}$ which involves the relations of Appendix A4 to obtain ℓ_1 from Eq. (A4. 17).

EARTHS — (Earth radius and gravity Subprogram) is

SUBROUTINE EARTH(ALAT, GEPHI, RPHI)

which calculates g_ϕ and r_ϕ from Eqs. (A8) and (A9) at latitude ALAT (= ϕ).

MSISINS — (MSIS variations included Subprogram) is

SUBROUTINE MSISIN

which lists those of the 23 variations of MSIS-86 that are being omitted when the Subroutine GTS5 is called.

THADATA — (Temperature high altitude Datafile) contains observed temperatures at 5-km height intervals from 70 to 130 km at different sites.

POLYTDD	(Specifies polynomial for obtaining temperature differences Datafile) is a file of input parameters for TDIFAVP4: IH1, IH2 = the range of data in THADATA to be utilized, NOBS = the number of single profiles to which a monthly mean is equated for purposes of weighting (arbitrarily chosen); ISLT = 0 or 1 according to whether local solar time is excluded or included in MSIS-86, ILONG1 = ILONG2 = 0 or 1 according to whether longitude dependences are excluded or included in lower model or upper model (that is, MSIS-86), NCOND = number of coefficients (= 7) of the interpolating polynomial between heights z_1 and z_2, NF107 (= 120) and NP (= 10) are values of solar activity parameters $F_{10.7}$ and A_p which are adopted when no other values are specified, NRUN = reference number assigned to a particular computer run, IMSIS = 0 for normal use of TDIFAVP4 and = 99 to give tables of T-TMSIS where T is a polynomial model temperature and TMSIS is the corresponding MSIS-86 value, ISAX (= 7) and INAX (= 2) are the values of S and N in Appendix B, NOSCZ1 = 0 for RNDEL to be set zero in BCZ12 so that no sunspot number dependence is introduced into the lower model.
DUMMYAXD	(Dummy set of a_{sn} coefficients Datafile) is datafile of a_{sn} all of which are zero.
TEMPS	(Temperature etc Subprogram) is

```
SUBROUTINE TEMP(ZHT1, ZHT2, ZHTD, IHEND, Z1, Z2,
     IDAY, MN, GLAT, GLONG, SLT, F107A, F107, AP, TT,
     DN, PR, TOTND, RCL, ZZTURB, DDFZ2, DMXZ2)
```

which calculates at each of IHEND heights from ZHT1 to ZHT2 at a height interval of ZHTD the temperature TT, the number densities of individual gas constituents DN(I), $I \neq 6$ and the total mass density DN(6), the total number density TOTND, the parameter RCL(I) [= R'_{1I} from Eq. (A5.16)], the 'turbopause' heights ZZTURB(I) [$=z_{hI}$ of Eq. (A97)], diffusion profile number densities DDFZ2(I) (= $n_d(z_2, M_I)$) and mixing profile number densities DMXZ2(I) (= $n_m(z_2, M_I)$) at height z_2 of the gas constituents.

LINES	(Line Subprogram) is

```
SUBROUTINE LINE(CHAR)
```

which reads in and writes out a line of characters.

CF1880S (Coefficients for 18 - 80 km model Subprogram) is

SUBROUTINE CF1880(CC, DELG, WAV)

which reads in TPW12Q and derives DELG and WAV for use in BCATZZS and then reads in COEFFDQ into CC.

CFZ1Z2S (Coefficients a_{sn} for z_1 to z_2 model Subprogram) is

SUBROUTINE CFZ1Z2

which reads in and writes out a_{sn}.

PARAMD (Parameter Datafile) runs TVALP with ZHT1, ZHT2, ZHTD; MN1, MN2, MND; LAT1, LAT2, LATD; LNG1, LNG2, LNGD; ISLT1, ISLT2, ISLTD as the ranges of height, month, latitude, longitude and local solar time and their respective increments at which values are required to be evaluated; IXLONG = 0 gives zonal mean values; ICHPAR, ITPDN, ICHNUM, IATMOS, ITMOSN = 0, 1 for output subroutines CHPARM, TPDN, CHNUM, ATMOS and ATMOSN not to be called or to be called; IXSLT = 0 gives diurnal mean values in MSIS-86; solar activity parameters for which TVALP is to run are listed as F107A, F107, AP(1), .. AP(7), SW(9), and NOSCZ1, where SW(9) controls the use of AP(I) in GTS5 (that is, MSIS-86) and NOSCZ1 = 0, 1 excludes or includes solar cycle dependence in the lower model according to SCATZ1.

PRM86D1 (Parameters for MSIS-86 Datafile with TVAL1KMP) gives ZHT1(= 65.), ZHT2 (= 135.), ZHTD (= 1.); LAT1 (= -80); LAT2 (= 80); LATD (= 10); LNG1, LNG2, LNGD; ISLT1, ISLT2, ISLTD as the ranges of height, latitude, longitude and local solar time and their respective increments at which values are required to be evaluated; IXLONG = 0 gives zonal mean values; IXSLT = 0 gives diurnal mean values in MSIS-86, ICHPAR (= 0), IATMOS (= 0); ITMOSN (= 0), ITPDTB (= 1) for output subroutines CHPARM, ATMOS, ATMOSN, TPDTB1 not to be called (= 0) or to be called (= 1); IMSIS = 0 for normal use, otherwise tables of values of MSIS-86 are generated; tables are generated for given dates specified by day of month and month as IDAT(I), MON(I), I = 1, .. NDAYS: IDAT(I) = 0 gives mid-month values; IXMN = 0 gives annual mean, = 1 for given dates as specified above; solar activity parameters for which TVAL1KMP is run and their controlling parameters SW(9) and NOSCZ1 are supplied as in PARAMD.

PRM86D5 (Parameters for MSIS-86 Datafile with TVAL5KMP) is the same as PRM86D1 with different height and latitude ranges; ZHT1 (= 70.), ZHT2 (= 130.), ZHTD (= 5.); LAT1 (= -80), LAT2 (= 80), LATD (= 20). Geostrophic W-E wind is not tabulated if IGEOTB = 0.

Appendix F

Tabulations of Temperatures, Pressures and Densities, 70-130 km

Diurnal and zonal means of mid-month values of temperature, pressure and density are presented as height-latitude cross-sections for:

(i) A_p = 4, and 132 and $F_{10.7}$ = 70 and 150 units corresponding to low and medium levels of solar activity. At intermediate levels of solar activity the tables may be interpolated linearly with respect to $F_{10.7}$ and log A_p.

(ii) A height interval of 5 km from 70 to 130 km. At intermediate heights, pressures and densities may be obtained by interpolation of their logarithms.

(iii) Case 1 of Section 4.1 using the coefficients in Table B1.

The tables match and are continuous with those of Reference A1 at 70 km and of Reference A2 (MSIS-86) at 130 km.

125	1.52	1.52	1.50	1.46	1.42	1.39	1.36	1.33	1.30
130	1.10	1.09	1.07	1.05	1.02	0.99	0.97	0.94	0.93

JANUARY DENSITY (KG/M CU)

70	1.34	1.23	1.02	0.91	0.90	0.87	0.72	0.60	0.53	- 4
75	6.92	6.13	4.86	4.36	4.39	4.17	3.41	2.88	2.60	- 5
80	3.20	2.77	2.16	1.96	1.98	1.90	1.59	1.37	1.24	
85	1.31	1.11	0.90	0.86	0.86	0.85	0.73	0.64	0.59	
90	4.71	4.06	3.61	3.71	3.65	3.66	3.36	3.00	2.66	- 6
95	1.56	1.43	1.41	1.53	1.48	1.50	1.49	1.37	1.15	
100	5.04	5.13	5.46	6.04	5.76	5.83	6.23	5.99	4.77	- 7
105	1.73	1.96	2.16	2.33	2.21	2.22	2.51	2.53	1.95	
110	0.66	0.82	0.90	0.93	0.88	0.88	1.02	1.06	0.82	
115	3.02	3.80	4.08	3.99	3.81	3.78	4.31	4.52	3.66	- 8
120	1.68	1.97	2.03	1.94	1.87	1.85	2.00	2.06	1.81	
125	1.08	1.13	1.13	1.09	1.06	1.05	1.07	1.06	1.01	
130	7.02	7.09	7.07	6.87	6.68	6.63	6.63	6.50	6.34	- 9

120	2.08	2.15	2.12	2.08	2.07	2.03	2.01	1.99	1.91
125	1.45	1.45	1.44	1.42	1.39	1.37	1.35	1.33	1.30
130	1.04	1.04	1.04	1.02	1.01	0.98	0.96	0.94	0.93

FEBRUARY DENSITY (KG/M CU)

70	1.10	1.06	0.96	0.91	0.92	0.89	0.73	0.61	0.58	- 4
75	5.59	5.19	4.55	4.40	4.45	4.25	3.47	2.97	2.92	- 5
80	2.55	2.33	2.04	2.00	2.01	1.96	1.62	1.42	1.41	
85	1.04	0.94	0.87	0.88	0.87	0.87	0.75	0.68	0.67	
90	3.88	3.53	3.50	3.72	3.63	3.71	3.37	3.16	3.05	- 6
95	1.35	1.29	1.35	1.50	1.48	1.50	1.44	1.41	1.28	
100	4.64	4.80	5.12	5.72	5.88	5.85	5.79	5.94	5.02	- 7
105	1.67	1.90	1.98	2.16	2.32	2.25	2.27	2.40	1.92	
110	6.67	8.13	8.15	8.50	9.43	8.99	9.09	9.69	7.61	- 8
115	3.07	3.79	3.68	3.68	4.07	3.88	3.91	4.12	3.33	
120	1.67	1.93	1.87	1.82	1.93	1.87	1.88	1.92	1.68	
125	1.04	1.09	1.08	1.05	1.04	1.03	1.04	1.03	0.98	
130	6.70	6.79	6.81	6.65	6.50	6.48	6.50	6.39	6.24	- 9

MARCH						TEMPERATURE (K)			
70	224	218	214	220	217	220	222	224	221
75	209	205	204	206	203	208	212	217	215
80	195	193	196	197	193	196	201	207	208
85	182	184	187	187	186	186	191	197	196
90	173	180	178	176	181	179	184	190	183
95	173	182	174	170	180	177	182	188	176
100	185	192	180	175	185	182	187	192	181
105	212	211	201	195	199	198	201	204	205
110	260	242	240	235	226	229	228	227	252
115	326	288	299	298	273	277	272	268	320
120	390	349	367	371	341	345	336	332	389
125	436	417	422	427	419	417	409	409	433
130	482	471	466	473	477	471	463	466	476

MARCH						PRESSURE (N/M SQ)				
70	4.66	5.02	5.38	5.72	5.78	5.61	5.03	4.35	3.94	+ 0
75	2.15	2.28	2.42	2.62	2.61	2.57	2.34	2.04	1.82	
80	0.94	0.98	1.05	1.14	1.12	1.13	1.04	0.93	0.83	
85	3.86	4.06	4.42	4.82	4.67	4.73	4.45	4.06	3.64	- 1
90	1.51	1.62	1.78	1.93	1.89	1.91	1.83	1.72	1.51	
95	5.79	6.51	6.95	7.43	7.59	7.54	7.42	7.18	5.98	- 2
100	2.31	2.72	2.76	2.87	3.10	3.04	3.06	3.04	2.38	
105	1.02	1.22	1.18	1.19	1.33	1.30	1.33	1.34	1.03	
110	5.17	6.02	5.71	5.67	6.29	6.15	6.31	6.40	5.09	- 3
115	3.03	3.33	3.20	3.16	3.36	3.31	3.37	3.39	2.94	
120	1.98	2.05	2.03	2.01	2.04	2.03	2.04	2.02	1.91	
125	1.37	1.39	1.39	1.39	1.38	1.37	1.37	1.35	1.33	
130	0.99	1.00	1.00	1.00	1.00	0.99	0.98	0.97	0.96	

MARCH						DENSITY (KG/M CU)				
70	7.26	9.03	8.74	9.06	9.29	9.88	7.89	6.76	6.21	- 5
75	3.58	3.96	4.13	4.41	4.49	4.31	3.83	3.28	2.96	
80	1.67	1.77	1.87	2.02	2.03	2.00	1.81	1.56	1.39	
85	7.38	7.68	8.23	8.99	8.76	8.83	8.13	7.18	6.45	- 6
90	3.02	3.14	3.48	3.81	3.63	3.70	3.46	3.14	2.87	
95	1.16	1.23	1.38	1.51	1.46	1.47	1.41	1.32	1.18	
100	4.29	4.84	5.23	5.62	5.73	5.70	5.60	5.42	4.50	- 7
105	1.62	1.95	1.97	2.06	2.26	2.20	2.23	2.22	1.69	
110	6.59	8.25	7.84	7.94	9.17	8.87	9.16	9.33	6.71	- 8
115	3.03	3.76	3.45	3.41	3.97	3.85	4.01	4.10	2.99	
120	1.62	1.87	1.75	1.71	1.89	1.86	1.92	1.95	1.58	
125	0.99	1.04	1.03	1.01	1.02	1.02	1.04	1.03	0.97	
130	6.40	6.52	6.58	6.48	6.39	6.42	6.47	6.38	6.25	- 9

APRIL						TEMPERATURE (K)			
70	233	226	218	218	212	219	222	224	225
75	225	218	209	206	201	205	208	212	213
80	215	210	202	198	194	194	195	197	198
85	200	200	192	188	190	187	184	184	181
90	186	190	180	176	187	183	177	175	169
95	179	186	174	170	184	184	177	173	166
100	184	189	178	174	187	189	185	182	176
105	204	203	197	193	197	200	202	204	207
110	244	232	236	233	220	223	233	242	262
115	303	279	296	296	263	264	280	297	339
120	369	343	363	368	332	330	345	364	408
125	423	410	416	424	416	413	416	426	446
130	468	460	458	469	478	476	471	478	490

APRIL						PRESSURE (N/M SQ)				
70	3.49	3.89	4.86	5.58	5.63	5.54	5.63	5.35	5.00	+ 0
75	1.68	1.83	2.22	2.53	2.51	2.57	2.59	2.49	2.33	
80	0.79	0.84	0.99	1.11	1.08	1.11	1.13	1.10	1.03	
85	3.52	3.71	4.23	4.68	4.54	4.64	4.68	4.58	4.28	- 1
90	1.48	1.58	1.73	1.88	1.89	1.89	1.86	1.80	1.65	
95	6.00	6.58	6.81	7.25	7.77	7.72	7.34	6.96	6.09	- 2
100	2.43	2.75	2.69	2.90	3.23	3.21	2.97	2.76	2.32	
105	1.06	1.21	1.13	1.16	1.39	1.40	1.29	1.19	0.99	
110	5.19	5.80	5.45	5.48	6.45	6.56	6.16	5.76	4.95	- 3
115	2.93	3.15	3.04	3.05	3.37	3.44	3.34	3.20	2.93	
120	1.87	1.93	1.93	1.94	2.01	2.04	2.04	2.01	1.94	
125	1.28	1.30	1.32	1.34	1.35	1.37	1.38	1.37	1.36	
130	9.24	9.35	9.53	9.68	9.79	9.87	9.89	9.85	9.82	- 4

APRIL						DENSITY (KG/M CU)				
70	5.21	6.00	7.77	8.94	9.24	8.96	8.84	8.31	7.73	- 5
75	2.60	2.92	3.70	4.29	4.35	4.36	4.33	4.09	3.81	
80	1.28	1.39	1.70	1.95	1.93	2.00	2.02	1.94	1.82	
85	6.12	6.47	7.69	8.69	8.31	8.65	8.87	8.67	8.22	- 6
90	2.77	2.89	3.34	3.71	3.51	3.58	3.65	3.59	3.40	
95	1.16	1.23	1.36	1.48	1.46	1.45	1.43	1.39	1.27	
100	4.53	4.99	5.16	5.50	5.91	5.82	5.50	5.19	4.50	- 7
105	1.75	2.00	1.93	2.01	2.37	2.35	2.14	1.96	1.61	
110	7.05	8.26	7.59	7.72	9.66	9.72	8.75	7.90	6.28	- 8
115	3.14	3.65	3.30	3.31	4.12	4.21	3.86	3.51	2.82	
120	1.61	1.78	1.67	1.65	1.91	1.96	1.88	1.77	1.53	
125	0.95	0.99	0.98	0.97	1.01	1.03	1.03	1.01	0.97	
130	6.07	6.21	6.30	6.26	6.24	6.34	6.44	6.40	6.29	- 9

AP = 4.0 F107 = 70.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

MAY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	234	233	223	212	208	216	216	220	224
75	229	223	213	201	196	201	199	202	203
80	221	213	206	197	192	190	185	184	183
85	210	204	197	191	191	184	176	171	167
90	197	199	187	181	189	182	173	167	158
95	190	195	180	173	187	184	177	171	160
100	191	196	181	175	189	190	189	185	175
105	205	203	195	192	198	202	211	211	209
110	234	221	226	229	221	226	244	251	266
115	281	256	277	289	263	268	291	304	343
120	343	317	343	360	330	333	353	366	409
125	406	393	403	418	413	414	419	428	449
130	455	447	448	462	474	475	474	483	497

MAY — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	2.89	3.45	4.38	5.35	5.44	5.66	5.94	6.38	6.81	+ 0
75	1.40	1.66	2.03	2.38	2.38	2.54	2.65	2.89	3.11	
80	0.67	0.77	0.92	1.03	1.01	1.08	1.11	1.21	1.31	
85	3.08	3.46	4.02	4.36	4.23	4.46	4.40	4.72	5.03	- 1
90	1.36	1.52	1.70	1.79	1.77	1.80	1.69	1.76	1.79	
95	5.78	6.58	6.90	7.06	7.39	7.34	6.57	6.56	6.28	- 2
100	2.45	2.87	2.79	2.76	3.10	3.06	2.68	2.60	2.33	
105	1.09	1.28	1.18	1.14	1.34	1.34	1.19	1.14	0.99	
110	5.27	6.05	5.55	5.36	6.25	6.32	5.87	5.67	4.98	- 3
115	2.87	3.14	2.99	2.94	3.26	3.33	3.25	3.20	2.95	
120	1.77	1.84	1.84	1.85	1.94	1.99	2.01	2.00	1.95	
125	1.19	1.21	1.24	1.27	1.30	1.33	1.35	1.36	1.36	
130	8.49	8.63	8.86	9.11	9.35	9.57	9.73	9.80	9.84	- 4

MAY — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	0.43	0.52	0.68	0.88	0.91	0.91	0.96	1.01	1.06	- 4
75	2.14	2.59	3.32	4.12	4.22	4.41	4.64	4.99	5.33	- 5
80	1.05	1.26	1.55	1.82	1.83	1.98	2.09	2.30	2.49	
85	0.51	0.59	0.71	0.80	0.77	0.84	0.87	0.96	1.05	
90	2.39	2.66	3.15	3.44	3.25	3.44	3.40	3.66	3.95	- 6
95	1.05	1.16	1.33	1.41	1.36	1.38	1.28	1.33	1.36	
100	4.39	5.00	5.26	5.38	5.62	5.52	4.86	4.81	4.57	- 7
105	1.79	2.12	2.03	2.00	2.28	2.23	1.91	1.83	1.60	
110	7.45	9.04	8.08	7.70	9.36	9.24	7.98	7.52	6.23	- 8
115	3.31	3.96	3.47	3.27	4.00	4.03	3.63	3.44	2.82	
120	1.63	1.84	1.69	1.61	1.86	1.90	1.81	1.76	1.54	
125	0.91	0.96	0.95	0.94	0.98	1.00	1.01	1.01	0.97	
130	5.72	5.87	5.98	5.98	6.02	6.18	6.34	6.35	6.26	- 9

JUNE — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	233	233	224	210	207	211	210	217	224
75	224	221	213	198	195	198	192	193	198
80	217	212	206	194	191	191	179	174	175
85	207	204	198	190	189	186	173	162	157
90	198	198	188	182	186	183	173	160	148
95	194	193	180	176	184	182	179	168	151
100	197	194	181	178	187	187	193	187	169
105	210	202	194	194	200	202	215	217	209
110	238	222	225	228	226	230	248	261	281
115	281	260	275	285	272	277	294	315	374
120	339	319	339	353	339	343	353	373	438
125	399	389	398	411	414	416	418	430	457
130	446	440	441	456	470	473	473	484	497

JUNE — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	2.64	3.34	4.19	5.22	5.25	5.48	6.02	7.25	8.21	+ 0
75	1.27	1.60	1.95	2.30	2.29	2.42	2.63	3.21	3.70	
80	0.59	0.74	0.88	0.98	0.96	1.03	1.07	1.29	1.51	
85	2.70	3.31	3.85	4.14	4.02	4.25	4.14	4.73	5.48	- 1
90	1.19	1.45	1.63	1.70	1.66	1.73	1.58	1.67	1.83	
95	5.13	6.24	6.67	6.77	6.85	7.00	6.15	6.07	6.00	- 2
100	2.23	2.69	2.70	2.68	2.84	2.88	2.54	2.39	2.12	
105	1.01	1.19	1.14	1.12	1.23	1.25	1.14	1.06	0.88	
110	4.99	5.62	5.34	5.25	5.77	5.91	5.70	5.40	4.53	- 3
115	2.74	2.94	2.86	2.85	3.06	3.16	3.17	3.10	2.78	
120	1.68	1.74	1.75	1.77	1.85	1.91	1.96	1.96	1.89	
125	1.12	1.15	1.17	1.20	1.24	1.28	1.32	1.34	1.34	
130	7.96	8.10	8.33	8.61	8.91	9.20	9.43	9.58	9.66	- 4

JUNE — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	0.39	0.50	0.65	0.87	0.88	0.91	1.00	1.16	1.28	- 4
75	1.96	2.52	3.20	4.04	4.08	4.26	4.75	5.77	6.52	- 5
80	0.95	1.21	1.49	1.76	1.76	1.87	2.07	2.58	3.00	
85	0.45	0.56	0.68	0.76	0.74	0.79	0.83	1.02	1.21	
90	2.08	2.55	3.01	3.24	3.10	3.28	3.17	3.64	4.29	- 6
95	0.91	1.12	1.28	1.33	1.28	1.33	1.19	1.25	1.38	
100	3.87	4.75	5.10	5.16	5.19	5.26	4.52	4.39	4.31	- 7
105	1.62	1.99	1.98	1.95	2.07	2.08	1.80	1.65	1.43	
110	6.94	8.37	7.83	7.58	8.44	8.52	7.65	6.89	5.38	- 8
115	3.16	3.66	3.35	3.24	3.64	3.71	3.52	3.23	2.44	
120	1.57	1.72	1.62	1.59	1.73	1.78	1.78	1.70	1.40	
125	8.77	9.13	9.11	9.07	9.36	9.67	9.95	9.91	9.39	- 9
130	5.46	5.61	5.73	5.75	5.82	6.01	6.21	6.24	6.18	

JULY								TEMPERATURE (K)	
70	230	227	220	211	211	211	209	215	224
75	220	217	210	200	197	200	194	191	196
80	211	211	205	194	191	195	184	172	174
85	202	207	199	187	186	190	178	162	158
90	196	202	191	180	182	183	176	162	150
95	193	197	184	176	180	179	179	170	153
100	198	195	184	180	184	182	190	189	170
105	213	200	195	197	200	198	211	219	208
110	242	217	221	231	230	230	244	260	272
115	286	253	266	284	280	284	294	311	357
120	343	313	329	350	347	353	356	369	422
125	401	389	395	410	416	420	419	427	452
130	448	441	442	456	469	471	471	481	475

AUGUST								TEMPERATURE (K)	
70	227	223	219	215	215	218	213	216	225
75	219	217	212	204	200	205	200	195	199
80	213	213	207	197	191	197	190	178	179
85	203	207	199	190	187	189	182	169	164
90	193	198	188	182	184	181	177	169	158
95	187	191	181	177	184	176	177	177	161
100	191	189	182	181	188	180	186	193	176
105	209	197	195	196	200	196	206	218	210
110	246	220	226	227	224	230	242	251	266
115	302	263	277	277	267	285	294	297	339
120	364	327	343	345	334	355	359	355	404
125	416	399	405	412	413	422	420	422	445
130	459	451	450	462	473	472	470	478	491

JULY							PRESSURE (N/M SQ)			
70	2.74	3.46	4.30	5.15	5.29	5.31	5.75	7.16	8.30	+ 0
75	1.30	1.63	1.98	2.28	2.34	2.35	2.50	3.13	3.74	
80	0.60	0.75	0.88	0.98	0.79	1.01	1.03	1.24	1.51	
85	2.67	3.36	3.87	4.10	4.10	4.28	4.11	4.55	5.51	- 1
90	1.16	1.49	1.65	1.66	1.66	1.76	1.61	1.62	1.86	
95	4.95	6.55	6.87	6.60	6.69	7.07	6.32	5.94	6.21	- 2
100	2.15	2.85	2.83	2.63	2.72	2.85	2.60	2.37	2.22	
105	0.98	1.26	1.21	1.12	1.17	1.21	1.15	1.06	0.93	
110	4.91	5.87	5.61	5.28	5.54	5.68	5.65	5.41	4.69	- 3
115	2.73	3.02	2.95	2.87	2.99	3.06	3.13	3.09	2.82	
120	1.68	1.76	1.77	1.78	1.83	1.88	1.93	1.95	1.89	
125	1.13	1.15	1.18	1.20	1.23	1.27	1.30	1.32	1.32	
130	7.99	8.12	8.33	8.58	8.85	9.11	9.32	9.45	9.53	- 4

AUGUST							PRESSURE (N/M SQ)			
70	3.02	3.83	4.43	5.28	5.49	5.46	5.51	6.34	7.03	+ 0
75	1.43	1.79	2.04	2.38	2.46	2.48	2.46	2.80	3.19	
80	0.66	0.82	0.92	1.04	1.05	1.08	1.04	1.14	1.31	
85	2.95	3.73	4.06	4.41	4.36	4.58	4.27	4.33	4.94	- 1
90	1.27	1.64	1.72	1.81	1.78	1.87	1.69	1.61	1.75	
95	5.33	7.04	7.04	7.23	7.30	7.42	6.67	6.16	6.14	- 2
100	2.24	2.98	2.85	2.90	3.03	2.95	2.70	2.53	2.30	
105	1.00	1.29	1.21	1.22	1.31	1.24	1.18	1.15	0.98	
110	4.96	6.00	5.68	5.74	6.16	5.81	5.72	5.76	4.96	- 3
115	2.81	3.13	3.05	3.08	3.24	3.14	3.17	3.22	2.93	
120	1.78	1.86	1.87	1.89	1.94	1.94	1.97	1.99	1.92	
125	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.34	1.34	
130	8.70	8.81	8.98	9.16	9.32	9.47	9.57	9.61	9.63	- 4

JULY							DENSITY (KG/M CU)			
70	0.41	0.53	0.68	0.85	0.87	0.87	0.96	1.16	1.29	- 4
75	2.06	2.61	3.27	3.98	4.12	4.09	4.50	5.73	6.62	- 5
80	0.99	1.23	1.50	1.76	1.81	1.81	1.96	2.52	3.02	
85	0.46	0.57	0.68	0.76	0.77	0.78	0.80	0.98	1.21	
90	2.05	2.57	3.01	3.21	3.18	3.34	3.17	3.48	4.30	- 6
95	0.88	1.15	1.29	1.29	1.29	1.37	1.22	1.21	1.40	
100	3.71	5.01	5.26	5.00	5.05	5.36	4.68	4.30	4.48	- 7
105	1.55	2.13	2.09	1.91	1.97	2.06	1.84	1.65	1.51	
110	6.72	8.95	8.39	7.56	7.96	8.17	7.68	6.94	5.75	- 8
115	3.09	3.86	3.58	3.27	3.46	3.51	3.48	3.26	2.60	
120	1.56	1.78	1.70	1.61	1.67	1.70	1.75	1.71	1.45	
125	8.78	9.21	9.22	9.10	9.26	9.52	9.84	9.86	9.40	- 9
130	5.48	5.62	5.73	5.75	5.80	5.98	6.17	6.19	6.13	

AUGUST							DENSITY (KG/M CU)			
70	0.46	0.60	0.70	0.86	0.89	0.87	0.90	1.02	1.09	- 4
75	2.27	2.87	3.35	4.06	4.27	4.21	4.27	5.02	5.57	- 5
80	1.08	1.34	1.55	1.84	1.91	1.91	1.91	2.23	2.55	
85	0.50	0.63	0.71	0.81	0.81	0.84	0.81	0.89	1.05	
90	2.30	2.88	3.18	3.45	3.36	3.59	3.32	3.31	3.86	- 6
95	0.99	1.28	1.35	1.41	1.37	1.46	1.30	1.20	1.32	
100	4.02	5.39	5.37	5.49	5.52	5.62	4.97	4.49	4.47	- 7
105	1.61	2.20	2.08	2.11	2.22	2.13	1.93	1.78	1.58	
110	6.67	9.01	8.28	8.36	9.10	8.37	7.86	7.63	6.22	- 8
115	3.02	3.86	3.55	3.59	3.93	3.58	3.50	3.56	2.83	
120	1.56	1.81	1.72	1.73	1.84	1.74	1.76	1.81	1.54	
125	0.92	0.96	0.96	0.96	0.98	0.98	1.00	1.01	0.96	
130	5.84	5.97	6.07	6.04	6.05	6.18	6.32	6.30	6.21	- 9

AP = 4.0 F107 = 70.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

SEPTEMBER — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	225	224	222	216	215	220	215	216	222
75	216	216	213	205	200	207	205	204	206
80	208	207	204	198	191	198	197	192	192
85	195	197	195	191	186	190	189	183	181
90	182	192	186	183	184	180	181	180	173
95	176	190	182	178	185	175	177	184	174
100	182	194	186	182	190	178	182	195	186
105	206	206	200	197	203	196	202	214	214
110	253	229	230	229	228	232	240	244	263
115	322	269	278	281	271	289	297	289	329
120	389	332	344	351	337	361	364	349	391
125	433	409	412	419	417	424	421	417	437
130	475	465	462	470	477	473	466	471	482

SEPTEMBER — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	3.97	4.30	4.81	5.49	5.59	5.57	5.24	5.03	4.78	+ 0
75	1.86	2.02	2.23	2.49	2.50	2.54	2.36	2.27	2.18	
80	0.84	0.92	1.00	1.09	1.07	1.12	1.03	0.97	0.94	
85	3.69	4.01	4.35	4.63	4.43	4.75	4.35	3.99	3.85	- 1
90	1.53	1.70	1.82	1.91	1.81	1.94	1.77	1.59	1.50	
95	6.05	7.17	7.43	7.65	7.43	7.66	7.02	6.42	5.75	- 2
100	2.42	3.06	3.05	3.08	3.11	3.03	2.82	2.70	2.30	
105	1.05	1.36	1.32	1.31	1.37	1.27	1.21	1.22	1.02	
110	5.22	6.53	6.28	6.18	6.50	6.00	5.85	6.07	5.20	- 3
115	3.02	3.47	3.39	3.34	3.46	3.28	3.26	3.36	3.05	
120	1.97	2.08	2.07	2.06	2.09	2.05	2.05	2.07	1.99	
125	1.37	1.39	1.40	1.40	1.40	1.40	1.40	1.39	1.38	
130	0.99	0.99	1.01	1.01	1.01	1.01	1.01	1.00	0.99	

SEPTEMBER — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	6.14	6.67	7.54	8.84	9.08	8.83	8.49	8.09	7.50	- 5
75	2.99	3.24	3.65	4.21	4.35	4.28	4.02	3.88	3.69	
80	1.41	1.54	1.71	1.91	1.95	1.96	1.81	1.77	1.71	
85	6.58	7.06	7.77	8.45	8.26	8.71	8.00	7.58	7.41	- 6
90	2.91	3.09	3.39	3.62	3.41	3.74	3.40	3.07	3.00	
95	1.19	1.30	1.41	1.48	1.39	1.52	1.37	1.21	1.14	
100	4.54	5.40	5.62	5.80	5.59	5.81	5.28	4.75	4.24	- 7
105	1.71	2.23	2.22	2.23	2.27	2.18	2.02	1.93	1.61	
110	6.82	9.45	9.01	8.89	9.43	8.54	8.07	8.25	6.56	- 8
115	3.05	4.18	3.93	3.83	4.13	3.66	3.55	3.78	3.03	
120	1.61	1.99	1.90	1.85	1.96	1.80	1.79	1.89	1.63	
125	0.99	1.06	1.05	1.04	1.04	1.03	1.04	1.05	1.00	
130	6.43	6.56	6.64	6.56	6.50	6.56	6.63	6.56	6.43	- 9

OCTOBER — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	226	226	223	218	212	217	217	223	231
75	213	213	210	204	200	206	209	215	222
80	199	199	198	196	194	199	204	208	213
85	183	185	189	191	190	190	196	200	200
90	171	177	182	187	189	181	185	192	189
95	167	176	181	186	189	175	179	189	183
100	178	186	187	190	193	179	182	192	189
105	208	209	205	202	204	198	200	207	210
110	263	247	237	227	227	235	237	235	250
115	339	302	288	271	268	294	294	281	308
120	407	366	353	338	335	363	361	344	372
125	446	426	419	416	416	422	416	410	424
130	489	477	470	475	478	469	458	460	470

OCTOBER — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	5.28	5.31	5.42	5.67	5.57	5.55	4.87	4.11	3.56	+ 0
75	2.47	2.48	2.50	2.57	2.47	2.52	2.22	1.91	1.70	
80	1.10	1.10	1.10	1.12	1.06	1.11	0.99	0.87	0.79	
85	4.58	4.63	4.67	4.72	4.46	4.72	4.30	3.84	3.52	- 1
90	1.78	1.84	1.90	1.96	1.86	1.93	1.80	1.65	1.49	
95	6.66	7.20	7.65	8.12	7.79	7.64	7.28	6.92	6.13	- 2
100	2.56	2.91	3.14	3.40	3.32	3.03	2.94	2.93	2.54	
105	1.10	1.27	1.37	1.49	1.47	1.28	1.26	1.31	1.13	
110	5.52	6.30	6.62	7.03	6.98	6.14	6.06	6.34	5.62	- 3
115	3.26	3.54	3.64	3.73	3.70	3.40	3.37	3.46	3.21	
120	2.16	2.23	2.25	2.25	2.22	2.14	2.13	2.12	2.05	
125	1.51	1.52	1.53	1.52	1.50	1.47	1.45	1.43	1.41	
130	1.09	1.10	1.10	1.09	1.08	1.07	1.05	1.02	1.01	

OCTOBER — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	8.13	8.19	8.47	9.09	9.17	8.90	7.82	6.42	5.36	- 5
75	4.02	4.05	4.16	4.38	4.31	4.26	3.70	3.09	2.67	
80	1.92	1.93	1.94	1.99	1.91	1.94	1.69	1.46	1.29	
85	8.70	8.69	8.60	8.62	8.16	8.62	7.65	6.69	6.11	- 6
90	3.63	3.62	3.63	3.64	3.42	3.71	3.38	2.97	2.75	
95	1.38	1.41	1.46	1.51	1.42	1.51	1.41	1.27	1.16	
100	4.92	5.34	5.73	6.14	5.87	5.78	5.51	5.22	4.60	- 7
105	1.78	2.06	2.25	2.48	2.42	2.18	2.11	2.13	1.81	
110	0.70	0.84	0.92	1.02	1.01	0.86	0.84	0.89	0.75	
115	3.14	3.81	4.09	4.45	4.44	3.72	3.68	3.97	3.38	- 8
120	1.70	1.94	2.02	2.11	2.10	1.86	1.85	1.95	1.75	
125	1.07	1.12	1.14	1.13	1.11	1.08	1.08	1.08	1.04	
130	7.00	7.12	7.16	7.03	6.89	6.90	6.92	6.80	6.64	- 9

NOVEMBER								TEMPERATURE (K)	
70	225	221	217	217	212	215	221	229	230
75	204	203	202	203	199	205	213	221	224
80	184	184	191	196	193	199	210	213	217
85	168	172	183	192	189	193	204	207	209
90	151	169	180	189	189	184	195	203	200
95	154	176	182	187	190	178	187	201	195
100	180	192	191	190	195	182	186	201	198
105	214	219	210	202	207	199	198	208	212
110	269	256	242	228	231	234	226	224	240
115	340	305	290	274	273	290	274	259	286
120	403	363	353	341	337	357	339	317	345
125	447	427	420	417	414	416	402	392	406
130	497	484	474	475	474	462	448	447	455

NOVEMBER								PRESSURE (N/M SQ)		
70	7.24	6.70	6.07	5.76	5.49	5.39	4.46	3.68	3.11	+ 0
75	3.32	3.04	2.74	2.60	2.44	2.43	2.07	1.75	1.49	
80	1.40	1.28	1.17	1.13	1.04	1.07	0.94	0.81	0.70	
85	5.41	4.99	4.78	4.77	4.35	4.57	4.21	3.66	3.19	- 1
90	1.96	1.87	1.92	2.00	1.81	1.90	1.84	1.63	1.41	
95	7.00	7.12	7.68	8.30	7.58	7.65	7.75	7.20	6.13	- 2
100	2.67	2.91	3.18	3.48	3.25	3.08	3.23	3.21	2.68	
105	1.16	1.31	1.41	1.52	1.45	1.32	1.39	1.46	1.22	
110	5.91	6.65	6.91	7.21	7.00	6.29	6.59	7.01	6.05	- 3
115	3.49	3.77	3.80	3.93	3.75	3.47	3.54	3.67	3.35	
120	2.29	2.36	2.35	2.31	2.26	2.17	2.16	2.16	2.07	
125	1.59	1.60	1.59	1.56	1.52	1.48	1.46	1.42	1.39	
130	1.15	1.15	1.14	1.12	1.09	1.07	1.04	1.01	1.00	

NOVEMBER								DENSITY (KG/M CU)		
70	1.12	1.06	0.97	0.93	0.90	0.87	0.70	0.56	0.47	- 4
75	5.66	5.23	4.72	4.46	4.26	4.14	3.37	2.75	2.32	- 5
80	2.65	2.42	2.13	2.00	1.88	1.86	1.56	1.32	1.12	
85	1.12	1.01	0.91	0.87	0.80	0.82	0.72	0.61	0.53	
90	4.23	3.85	3.69	3.68	3.34	3.58	3.27	2.78	2.45	- 6
95	1.48	1.40	1.46	1.53	1.38	1.48	1.43	1.24	1.08	
100	5.08	5.18	5.70	6.26	5.69	5.80	5.92	5.44	4.61	- 7
105	1.83	2.03	2.27	2.53	2.36	2.22	2.36	2.37	1.94	
110	0.73	0.86	0.95	1.04	1.00	0.88	0.96	1.03	0.83	
115	3.37	4.04	4.26	4.54	4.43	3.84	4.14	4.57	3.79	- 8
120	1.94	2.09	2.12	2.16	2.12	1.91	2.00	2.15	1.90	
125	1.14	1.19	1.13	1.16	1.14	1.10	1.11	1.12	1.07	
130	7.32	7.42	7.42	7.23	7.04	7.00	7.00	6.86	6.68	- 9

DECEMBER								TEMPERATURE (K)	
70	225	219	213	215	215	216	220	230	232
75	199	195	195	201	200	203	214	223	225
80	176	174	183	194	193	198	213	216	218
85	159	163	176	189	188	193	208	210	210
90	151	162	177	185	184	185	199	203	201
95	155	172	184	184	182	179	189	198	196
100	175	194	198	189	188	181	186	197	199
105	216	226	218	205	204	197	195	205	212
110	286	268	248	235	237	231	221	225	239
115	372	316	290	284	288	285	267	263	282
120	432	371	349	350	353	352	332	321	340
125	455	428	417	419	418	411	396	390	399
130	499	485	474	474	471	456	441	439	445

DECEMBER								PRESSURE (N/M SQ)		
70	8.64	7.59	6.36	5.77	5.54	5.44	4.35	3.50	2.95	+ 0
75	3.92	3.38	2.81	2.58	2.47	2.45	2.02	1.67	1.42	
80	1.60	1.37	1.16	1.11	1.06	1.07	0.92	0.78	0.67	
85	5.36	5.04	4.56	4.65	4.43	4.57	4.20	3.57	3.07	- 1
90	1.99	1.80	1.78	1.92	1.82	1.90	1.86	1.60	1.36	
95	6.66	6.62	7.11	7.82	7.37	7.69	7.94	7.03	5.94	- 2
100	2.43	2.68	3.01	3.24	3.04	3.10	3.32	3.08	2.61	
105	1.04	1.23	1.38	1.42	1.33	1.32	1.42	1.39	1.19	
110	5.41	6.38	6.88	6.80	6.41	6.25	6.61	6.62	5.92	- 3
115	3.32	3.69	3.81	3.69	3.51	3.41	3.49	3.50	3.27	
120	2.25	2.33	2.33	2.26	2.18	2.12	2.11	2.08	2.01	
125	1.58	1.58	1.56	1.52	1.48	1.44	1.41	1.37	1.35	
130	1.14	1.13	1.12	1.09	1.06	1.03	1.00	0.97	0.96	

DECEMBER								DENSITY (KG/M CU)		
70	1.34	1.21	1.04	0.94	0.90	0.88	0.69	0.53	0.44	- 4
75	6.36	6.03	5.00	4.47	4.30	4.20	3.27	2.61	2.19	- 5
80	3.17	2.73	2.21	1.99	1.91	1.87	1.51	1.26	1.07	
85	1.28	1.08	0.90	0.86	0.82	0.92	0.70	0.59	0.51	
90	4.57	3.86	3.49	3.60	3.44	3.57	3.25	2.73	2.36	- 6
95	1.49	1.33	1.33	1.47	1.40	1.48	1.45	1.23	1.05	
100	4.77	4.75	5.21	5.38	5.54	5.85	6.11	5.34	4.48	- 7
105	1.63	1.94	2.13	2.34	2.18	2.25	2.45	2.28	1.39	
110	6.33	7.94	9.22	9.59	8.94	8.91	9.34	9.70	8.16	- 8
115	2.94	3.92	4.27	4.22	3.95	3.85	4.20	4.29	3.73	
120	1.69	2.03	2.14	2.06	1.95	1.89	2.00	2.04	1.87	
125	1.12	1.18	1.18	1.14	1.10	1.08	1.10	1.09	1.05	
130	7.29	7.37	7.34	7.12	6.91	6.86	6.85	6.71	6.54	- 9

AP =132.0   F107 = 70.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

JANUARY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	226	220	213	216	219	219	220	224	228
75	200	196	198	204	203	207	215	221	221
80	177	177	187	198	195	199	211	217	214
85	161	166	181	192	189	192	205	212	204
90	154	164	179	185	182	183	197	205	196
95	158	173	183	181	178	177	190	200	193
100	179	194	195	185	183	181	190	200	200
105	225	229	218	202	201	199	201	209	221
110	310	283	257	238	236	236	229	233	263
115	433	355	316	297	293	295	282	283	331
120	537	440	395	374	366	370	362	368	424
125	576	521	476	448	435	438	448	475	517
130	620	584	537	504	490	488	503	541	578

JANUARY — PRESSURE (N/M SQ)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	8.71	7.73	6.24	5.66	5.67	5.43	4.54	3.88	3.47	+ 0
75	3.97	3.46	2.76	2.55	2.56	2.48	2.11	1.83	1.65	
80	1.63	1.41	1.16	1.11	1.11	1.09	0.96	0.85	0.76	
85	6.04	5.29	4.68	4.76	4.67	4.66	4.34	3.92	3.44	- 1
90	2.08	1.92	1.86	1.98	1.91	1.92	1.91	1.77	1.50	
95	7.16	7.18	7.43	8.02	7.65	7.71	8.16	7.90	6.42	- 2
100	2.68	2.92	3.11	3.27	3.09	3.10	3.47	3.51	2.80	
105	1.18	1.35	1.41	1.41	1.33	1.33	1.52	1.60	1.30	
110	6.40	7.15	7.16	6.78	6.38	6.38	7.29	7.79	6.72	- 3
115	4.14	4.32	4.10	3.76	3.52	3.55	3.96	4.24	3.96	
120	2.99	2.89	2.63	2.37	2.22	2.25	2.47	2.64	2.63	
125	2.26	2.08	1.84	1.65	1.53	1.56	1.71	1.84	1.90	
130	1.73	1.57	1.36	1.21	1.12	1.14	1.27	1.38	1.44	

JANUARY — DENSITY (KG/M CU)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	1.34	1.23	1.02	0.91	0.90	0.87	0.72	0.60	0.53	- 4
75	6.92	6.13	4.86	4.36	4.39	4.17	3.41	2.89	2.60	- 5
80	3.20	2.77	2.16	1.96	1.98	1.90	1.59	1.37	1.25	
85	1.31	1.11	0.90	0.86	0.86	0.85	0.74	0.65	0.59	
90	4.72	4.07	3.61	3.71	3.65	3.66	3.36	3.00	2.67	- 6
95	1.57	1.44	1.41	1.54	1.48	1.50	1.48	1.37	1.15	
100	5.15	5.19	5.49	6.06	5.78	5.85	6.25	6.03	4.83	- 7
105	1.80	2.01	2.20	2.35	2.23	2.24	2.55	2.60	2.01	
110	0.70	0.85	0.93	0.94	0.89	0.89	1.05	1.12	0.87	
115	3.22	4.06	4.27	4.10	3.88	3.88	4.56	4.94	4.01	- 8
120	1.86	2.18	2.17	2.02	1.92	1.92	2.17	2.33	2.06	
125	1.30	1.31	1.25	1.15	1.09	1.11	1.19	1.25	1.22	
130	9.23	8.77	8.08	7.41	6.97	7.14	7.74	8.09	8.18	- 9

FEBRUARY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	223	217	213	218	217	218	221	227	232
75	199	196	200	204	203	207	214	222	222
80	179	179	189	196	194	198	208	218	214
85	166	170	180	188	188	189	200	210	201
90	161	170	176	180	183	181	190	200	188
95	166	179	178	176	182	178	184	192	182
100	186	199	190	181	186	183	187	192	188
105	228	231	216	201	200	200	203	206	213
110	302	277	261	241	229	233	238	238	265
115	408	341	326	305	278	288	297	298	350
120	509	425	406	383	350	362	380	390	454
125	566	514	479	452	431	439	460	490	535
130	616	580	534	504	493	494	513	553	589

FEBRUARY — PRESSURE (N/M SQ)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	7.06	6.58	5.86	5.71	5.74	5.55	4.61	3.99	3.89	+ 0
75	3.19	2.93	2.61	2.59	2.59	2.53	2.14	1.90	1.86	
80	1.32	1.20	1.11	1.13	1.12	1.11	0.97	0.89	0.87	
85	5.00	4.60	4.50	4.74	4.68	4.73	4.31	4.08	3.88	- 1
90	1.80	1.73	1.77	1.92	1.92	1.94	1.84	1.82	1.65	
95	6.52	6.68	6.96	7.61	7.79	7.75	7.64	7.83	6.74	- 2
100	2.56	2.81	2.86	3.04	3.21	3.14	3.17	3.35	2.78	
105	1.16	1.32	1.29	1.30	1.39	1.35	1.39	1.49	1.24	
110	6.28	6.99	6.56	6.32	6.63	6.47	6.75	7.27	6.33	- 3
115	4.00	4.18	3.82	3.56	3.57	3.56	3.77	4.04	3.79	
120	2.85	2.77	2.50	2.28	2.19	2.23	2.40	2.58	2.59	
125	2.13	1.98	1.77	1.60	1.50	1.54	1.69	1.83	1.90	
130	1.64	1.50	1.32	1.17	1.10	1.13	1.25	1.37	1.45	

FEBRUARY — DENSITY (KG/M CU)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	1.10	1.06	0.96	0.91	0.92	0.89	0.73	0.61	0.58	- 4
75	5.59	5.19	4.55	4.40	4.45	4.26	3.47	2.97	2.92	- 5
80	2.55	2.33	2.04	2.00	2.01	1.96	1.63	1.42	1.41	
85	1.05	0.94	0.87	0.88	0.87	0.87	0.75	0.68	0.67	
90	3.89	3.53	3.50	3.72	3.63	3.71	3.37	3.16	3.06	- 6
95	1.36	1.29	1.35	1.50	1.48	1.50	1.44	1.41	1.29	
100	4.73	4.85	5.16	5.74	5.90	5.87	5.82	5.99	5.10	- 7
105	1.74	1.95	2.01	2.18	2.34	2.27	2.31	2.47	1.99	
110	0.70	0.85	0.84	0.87	0.96	0.92	0.94	1.02	0.81	
115	3.30	4.08	3.84	3.78	4.15	3.99	4.12	4.49	3.64	- 8
120	1.87	2.15	1.99	1.89	1.98	1.94	2.02	2.16	1.90	
125	1.25	1.26	1.18	1.10	1.08	1.09	1.15	1.20	1.18	
130	8.77	8.38	7.79	7.16	6.79	6.98	7.56	7.94	8.10	- 9

MARCH								TEMPERATURE (K)	
70	224	218	214	220	217	220	222	224	221
75	209	205	204	206	203	208	212	217	215
80	195	193	196	197	193	196	201	206	208
85	182	184	187	187	186	186	190	197	197
90	175	181	178	176	181	179	184	191	184
95	176	185	175	171	180	178	183	191	179
100	192	198	184	176	186	184	190	198	188
105	228	223	208	198	201	202	208	215	220
110	293	265	255	242	230	235	241	248	283
115	391	328	327	311	279	288	295	304	383
120	492	415	413	392	351	363	375	391	492
125	558	508	481	455	434	443	464	497	556
130	609	572	529	504	496	502	525	567	603

MARCH								PRESSURE (N/M SQ)		
70	4.66	5.02	5.38	5.72	5.78	5.61	5.03	4.35	3.94	+ 0
75	2.15	2.28	2.42	2.62	2.61	2.57	2.34	2.04	1.83	
80	0.94	0.98	1.05	1.15	1.13	1.13	1.04	0.93	0.83	
85	3.97	4.06	4.43	4.82	4.67	4.73	4.45	4.06	3.65	- 1
90	1.52	1.63	1.78	1.93	1.89	1.91	1.83	1.73	1.52	
95	5.93	6.62	7.02	7.47	7.62	7.58	7.48	7.29	6.12	- 2
100	2.43	2.83	2.82	2.91	3.13	3.08	3.13	3.16	2.50	
105	1.12	1.31	1.24	1.23	1.36	1.33	1.40	1.45	1.13	
110	6.04	6.83	6.20	5.94	6.48	6.44	6.87	7.26	5.94	- 3
115	3.81	4.01	3.62	3.38	3.51	3.55	3.83	4.09	3.69	
120	2.69	2.64	2.40	2.20	2.16	2.23	2.42	2.61	2.60	
125	2.01	1.89	1.72	1.56	1.49	1.54	1.69	1.85	1.94	
130	1.54	1.43	1.28	1.15	1.09	1.14	1.26	1.39	1.49	

MARCH								DENSITY (KG/M CU)		
70	7.26	8.03	8.74	9.06	9.29	8.98	7.89	6.76	6.21	- 5
75	3.59	3.96	4.13	4.41	4.49	4.31	3.83	3.28	2.96	
80	1.68	1.78	1.87	2.02	2.03	2.00	1.81	1.57	1.39	
85	7.39	7.69	8.24	8.98	8.76	8.83	8.13	7.19	6.46	- 6
90	3.03	3.14	3.48	3.81	3.63	3.70	3.46	3.14	2.88	
95	1.17	1.24	1.33	1.51	1.46	1.48	1.41	1.32	1.18	
100	4.37	4.89	5.27	5.64	5.75	5.72	5.63	5.48	4.58	- 7
105	1.68	2.00	2.01	2.03	2.27	2.22	2.27	2.29	1.75	
110	6.97	8.66	8.08	8.09	9.29	9.04	9.47	9.35	7.11	- 8
115	3.27	4.05	3.60	3.50	4.05	3.97	4.23	4.47	3.24	
120	1.82	2.08	1.86	1.77	1.94	1.93	2.07	2.19	1.76	
125	1.19	1.21	1.13	1.06	1.06	1.08	1.15	1.21	1.16	
130	8.31	8.03	7.55	6.97	6.67	6.91	7.46	7.90	8.13	- 9

APRIL								TEMPERATURE (K)	
70	233	226	218	218	212	219	222	224	225
75	225	218	209	206	201	205	208	212	213
80	215	209	202	197	194	194	194	197	193
85	200	200	191	188	190	187	184	184	182
90	188	191	180	176	187	184	178	176	170
95	183	188	175	170	185	185	179	176	169
100	191	195	181	175	188	190	189	188	183
105	218	214	204	196	199	203	210	215	221
110	272	253	250	240	223	229	246	265	296
115	359	318	323	309	269	274	304	341	410
120	462	409	410	389	341	347	385	435	520
125	542	501	475	452	430	439	473	519	571
130	597	560	520	499	497	506	535	579	616

APRIL								PRESSURE (N/M SQ)		
70	3.49	3.89	4.86	5.58	5.63	5.64	5.63	5.35	5.00	+ 0
75	1.68	1.83	2.22	2.53	2.51	2.57	2.59	2.49	2.33	
80	0.79	0.84	0.99	1.11	1.08	1.11	1.13	1.10	1.03	
85	3.53	3.72	4.23	4.68	4.54	4.64	4.68	4.58	4.29	- 1
90	1.50	1.59	1.73	1.88	1.89	1.89	1.87	1.82	1.66	
95	6.13	6.68	6.87	7.29	7.80	7.76	7.41	7.08	6.23	- 2
100	2.55	2.85	2.75	2.83	3.26	3.26	3.05	2.87	2.44	
105	1.16	1.30	1.19	1.19	1.41	1.44	1.35	1.28	1.09	
110	6.03	6.57	5.93	5.74	6.64	6.87	6.69	6.53	5.80	- 3
115	3.66	3.79	3.45	3.26	3.51	3.68	3.77	3.86	3.69	
120	2.52	2.48	2.29	2.12	2.13	2.24	2.41	2.58	2.64	
125	1.86	1.78	1.64	1.50	1.45	1.53	1.69	1.86	1.99	
130	1.42	1.34	1.23	1.11	1.07	1.13	1.26	1.41	1.53	

APRIL								DENSITY (KG/M CU)		
70	5.21	6.00	7.77	8.94	9.24	8.96	8.84	8.31	7.73	- 5
75	2.60	2.92	3.70	4.29	4.35	4.36	4.33	4.09	3.81	
80	1.28	1.39	1.70	1.96	1.93	2.00	2.02	1.94	1.82	
85	6.13	6.48	7.70	8.69	8.31	8.65	8.37	8.68	8.23	- 6
90	2.78	2.89	3.34	3.71	3.51	3.58	3.65	3.60	3.41	
95	1.16	1.23	1.36	1.48	1.46	1.45	1.43	1.39	1.28	
100	4.60	5.04	5.19	5.52	5.93	5.85	5.53	5.26	4.59	- 7
105	1.31	2.06	1.97	2.03	2.39	2.38	2.18	2.02	1.63	
110	7.48	9.69	7.82	7.86	9.79	9.92	9.04	8.30	6.64	- 8
115	3.42	3.94	3.45	3.39	4.21	4.34	4.05	3.77	3.02	
120	1.81	1.98	1.78	1.71	1.96	2.05	2.01	1.95	1.70	
125	1.13	1.15	1.08	1.02	1.04	1.09	1.13	1.17	1.16	
130	7.82	7.65	7.28	6.74	6.52	6.82	7.38	7.88	8.17	- 9

AP =132.0   F107 = 70.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

MAY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	234	233	223	212	208	216	216	220	224
75	228	223	213	201	196	201	199	202	203
80	221	213	206	197	192	190	185	184	183
85	210	204	197	191	191	184	176	171	167
90	199	200	187	181	189	183	173	167	159
95	194	198	181	174	188	185	179	174	162
100	199	202	184	177	190	192	193	191	181
105	219	214	202	195	200	206	218	224	224
110	261	240	239	236	224	232	258	276	301
115	330	290	302	301	268	278	317	349	415
120	426	374	385	381	340	350	395	438	520
125	522	480	460	445	427	440	476	521	572
130	584	548	509	493	493	506	538	585	621

JUNE — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	233	233	224	210	207	211	210	217	224
75	224	221	212	198	195	198	192	193	196
80	216	211	205	194	191	191	179	173	175
85	207	204	198	190	189	186	173	162	158
90	200	198	188	182	187	183	173	161	149
95	198	196	182	176	185	183	181	170	154
100	205	200	184	179	188	189	197	193	175
105	226	213	201	197	201	205	223	231	225
110	266	242	238	235	229	236	263	288	320
115	332	296	300	297	278	288	321	364	462
120	422	380	382	374	349	361	396	448	568
125	514	478	455	439	428	442	476	524	585
130	576	540	502	487	489	503	539	585	621

MAY — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	2.89	3.45	4.38	5.35	5.44	5.66	5.94	6.38	6.81	+ 0
75	1.40	1.66	2.03	2.38	2.38	2.54	2.65	2.89	3.11	
80	0.67	0.77	0.92	1.03	1.01	1.08	1.11	1.21	1.31	
85	3.08	3.47	4.02	4.36	4.23	4.46	4.40	4.73	5.04	- 1
90	1.37	1.52	1.70	1.79	1.77	1.81	1.70	1.77	1.81	
95	5.90	6.67	6.94	7.09	7.42	7.38	6.64	6.67	6.44	- 2
100	2.57	2.97	2.85	2.80	3.13	3.10	2.75	2.71	2.46	
105	1.19	1.38	1.24	1.17	1.37	1.37	1.25	1.23	1.09	
110	6.10	6.85	6.05	5.61	6.44	6.62	6.37	6.44	5.86	- 3
115	3.59	3.79	3.41	3.15	3.40	3.57	3.67	3.86	3.74	
120	2.38	2.38	2.20	2.03	2.05	2.18	2.36	2.58	2.67	
125	1.73	1.67	1.55	1.42	1.40	1.49	1.66	1.86	2.01	
130	1.31	1.25	1.15	1.05	1.02	1.10	1.23	1.40	1.54	

JUNE — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	2.64	3.34	4.19	5.22	5.25	5.48	6.02	7.25	8.21	+ 0
75	1.27	1.60	1.95	2.30	2.29	2.42	2.63	3.21	3.70	
80	0.59	0.74	0.88	0.98	0.96	1.03	1.07	1.29	1.51	
85	2.71	3.31	3.85	4.14	4.02	4.25	4.14	4.74	5.50	- 1
90	1.20	1.45	1.63	1.70	1.67	1.73	1.58	1.68	1.85	
95	5.22	6.32	6.71	6.80	6.88	7.03	6.22	6.18	6.15	- 2
100	2.33	2.78	2.76	2.71	2.87	2.92	2.61	2.49	2.24	
105	1.10	1.28	1.20	1.15	1.25	1.28	1.20	1.15	0.98	
110	5.78	6.38	5.62	5.49	5.94	6.19	6.19	6.14	5.34	- 3
115	3.42	3.56	3.27	3.06	3.20	3.38	3.58	3.74	3.53	
120	2.27	2.26	2.10	1.95	1.96	2.10	2.31	2.53	2.61	
125	1.64	1.59	1.48	1.35	1.34	1.44	1.62	1.83	1.98	
130	1.24	1.19	1.09	0.99	0.97	1.06	1.20	1.38	1.52	

MAY — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	0.43	0.52	0.68	0.88	0.91	0.91	0.96	1.01	1.06	- 4
75	2.14	2.59	3.33	4.12	4.22	4.41	4.65	4.99	5.33	- 5
80	1.05	1.26	1.55	1.82	1.83	1.98	2.10	2.30	2.49	
85	0.51	0.59	0.71	0.80	0.77	0.84	0.87	0.96	1.05	
90	2.40	2.66	3.15	3.44	3.25	3.44	3.40	3.67	3.96	- 6
95	1.06	1.16	1.33	1.41	1.36	1.38	1.28	1.33	1.37	
100	4.45	5.04	5.29	5.40	5.63	5.54	4.89	4.87	4.67	- 7
105	1.85	2.18	2.07	2.02	2.30	2.25	1.94	1.88	1.67	
110	7.92	9.54	8.34	7.83	9.49	9.43	8.22	7.88	6.59	- 8
115	3.64	4.32	3.65	3.35	4.09	4.16	3.80	3.68	3.03	
120	1.86	2.07	1.81	1.67	1.91	1.98	1.94	1.94	1.71	
125	1.09	1.12	1.05	0.99	1.01	1.06	1.11	1.17	1.16	
130	7.37	7.27	6.97	6.45	6.29	6.66	7.24	7.81	8.20	- 9

JUNE — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	0.39	0.50	0.65	0.87	0.88	0.91	1.00	1.16	1.28	- 4
75	1.97	2.52	3.20	4.04	4.08	4.26	4.75	5.78	6.53	- 5
80	0.96	1.22	1.49	1.76	1.76	1.87	2.07	2.58	3.00	
85	0.45	0.57	0.68	0.76	0.74	0.79	0.83	1.02	1.21	
90	2.09	2.55	3.01	3.24	3.10	3.29	3.18	3.64	4.31	- 6
95	0.92	1.12	1.28	1.33	1.29	1.33	1.19	1.26	1.39	
100	3.91	4.78	5.12	5.17	5.21	5.29	4.55	4.45	4.41	- 7
105	1.67	2.04	2.01	1.96	2.09	2.11	1.83	1.70	1.49	
110	7.35	8.81	8.08	7.71	8.55	8.68	7.87	7.19	5.65	- 8
115	3.46	3.98	3.53	3.32	3.71	3.82	3.68	3.44	2.57	
120	1.79	1.94	1.75	1.64	1.78	1.85	1.90	1.87	1.54	
125	1.05	1.07	1.02	0.96	0.97	1.02	1.09	1.15	1.13	
130	7.08	7.00	6.71	6.20	6.08	6.48	7.09	7.20	8.12	- 9

JULY						TEMPERATURE (K)			
70	230	227	220	211	211	211	209	215	224
75	219	217	210	200	197	200	194	191	196
80	211	211	204	194	191	195	184	172	174
85	202	207	198	187	186	190	178	162	159
90	197	203	191	180	182	184	177	162	152
95	197	200	186	177	180	180	181	173	156
100	207	201	188	182	185	184	194	195	177
105	229	211	202	200	202	201	219	232	223
110	272	236	233	237	234	237	259	287	309
115	338	286	289	296	286	295	321	359	436
120	428	371	369	370	358	373	399	442	543
125	517	476	451	437	431	447	477	521	578
130	577	541	503	488	489	502	536	583	619

JULY						PRESSURE (N/M SQ)				
70	2.74	3.46	4.30	5.15	5.29	5.31	5.75	7.16	8.30	+ 0
75	1.30	1.63	1.98	2.29	2.34	2.35	2.50	3.14	3.74	
80	0.60	0.75	0.88	0.98	0.99	1.01	1.03	1.24	1.51	
85	2.67	3.37	3.87	4.10	4.10	4.28	4.11	4.56	5.53	- 1
90	1.16	1.50	1.65	1.67	1.67	1.76	1.61	1.63	1.88	
95	5.04	6.63	6.92	6.62	6.72	7.11	6.39	6.05	6.36	- 2
100	2.25	2.95	2.90	2.67	2.75	2.89	2.66	2.47	2.35	
105	1.07	1.36	1.27	1.14	1.19	1.24	1.21	1.15	1.03	
110	5.70	6.66	6.12	5.52	5.71	5.95	6.14	6.16	5.54	- 3
115	3.41	3.65	3.37	3.08	3.12	3.28	3.54	3.74	3.59	
120	2.28	2.29	2.12	1.95	1.94	2.06	2.28	2.51	2.60	
125	1.65	1.59	1.48	1.35	1.33	1.43	1.60	1.81	1.97	
130	1.25	1.19	1.09	0.99	0.97	1.05	1.19	1.36	1.51	

JULY						DENSITY (KG/M CU)				
70	0.41	0.53	0.68	0.85	0.87	0.87	0.96	1.16	1.29	- 4
75	2.07	2.61	3.27	3.98	4.12	4.10	4.50	5.73	6.62	- 5
80	0.99	1.23	1.51	1.76	1.81	1.81	1.96	2.52	3.02	
85	0.46	0.57	0.68	0.76	0.77	0.78	0.80	0.98	1.21	
90	2.06	2.57	3.01	3.21	3.19	3.34	3.17	3.49	4.32	- 6
95	0.89	1.15	1.29	1.29	1.29	1.37	1.22	1.21	1.41	
100	3.75	5.04	5.28	5.01	5.07	5.38	4.71	4.36	4.58	- 7
105	1.60	2.18	2.12	1.92	1.99	2.08	1.87	1.69	1.53	
110	7.10	9.45	8.68	7.69	8.06	8.33	7.92	7.25	6.07	- 8
115	3.38	4.22	3.78	3.36	3.52	3.61	3.64	3.49	2.77	
120	1.77	2.01	1.83	1.67	1.72	1.77	1.86	1.89	1.61	
125	1.06	1.08	1.03	0.96	0.96	1.00	1.03	1.15	1.13	
130	7.11	7.02	6.71	6.19	6.06	6.45	7.05	7.65	9.07	- 9

AUGUST						TEMPERATURE (K)			
70	227	223	219	215	215	218	213	216	225
75	219	217	212	204	200	205	200	194	199
80	212	213	207	197	191	197	190	177	179
85	204	207	198	190	187	189	182	169	165
90	194	199	188	182	185	181	178	170	159
95	190	193	182	178	184	177	179	180	164
100	198	195	185	182	189	181	190	200	183
105	224	208	202	199	202	199	214	231	225
110	276	240	239	233	227	236	256	276	300
115	359	297	302	289	272	296	321	340	410
120	458	387	385	364	343	375	403	423	513
125	535	489	462	439	428	449	478	513	567
130	589	552	512	494	492	503	534	580	616

AUGUST						PRESSURE (N/M SQ)				
70	3.02	3.83	4.43	5.28	5.49	5.46	5.51	6.34	7.03	+ 0
75	1.43	1.79	2.04	2.38	2.46	2.48	2.46	2.80	3.19	
80	0.66	0.82	0.92	1.04	1.05	1.08	1.04	1.14	1.31	
85	2.96	3.73	4.06	4.41	4.36	4.58	4.27	4.33	4.95	- 1
90	1.28	1.65	1.73	1.81	1.79	1.87	1.70	1.62	1.76	
95	5.44	7.14	7.10	7.26	7.32	7.45	6.73	6.26	6.29	- 2
100	2.34	3.09	2.92	2.94	3.06	2.99	2.77	2.64	2.42	
105	1.09	1.39	1.27	1.26	1.34	1.27	1.23	1.24	1.08	
110	5.76	6.81	6.19	6.01	6.34	6.08	6.22	6.55	5.83	- 3
115	3.51	3.79	3.47	3.30	3.38	3.36	3.58	3.90	3.71	
120	2.41	2.41	2.23	2.07	2.05	2.13	2.33	2.57	2.64	
125	1.77	1.70	1.57	1.43	1.39	1.48	1.64	1.84	1.98	
130	1.35	1.28	1.17	1.05	1.02	1.09	1.22	1.38	1.51	

AUGUST						DENSITY (KG/M CU)				
70	0.46	0.60	0.70	0.86	0.89	0.97	0.90	1.02	1.09	- 4
75	2.27	2.87	3.35	4.06	4.27	4.21	4.28	5.02	5.57	- 5
80	1.08	1.35	1.55	1.84	1.91	1.91	1.91	2.24	2.56	
85	0.51	0.63	0.71	0.81	0.81	0.94	0.82	0.89	1.05	
90	2.30	2.98	3.18	3.45	3.36	3.59	3.32	3.32	3.97	- 6
95	0.99	1.28	1.35	1.41	1.37	1.46	1.30	1.21	1.33	
100	4.07	5.44	5.40	5.51	5.53	5.54	5.01	4.54	4.56	- 7
105	1.66	2.26	2.12	2.13	2.23	2.15	1.96	1.83	1.65	
110	7.06	9.52	8.56	9.52	9.22	8.53	8.10	8.00	6.59	- 8
115	3.28	4.21	3.74	3.69	4.01	3.68	3.67	3.93	3.05	
120	1.75	2.03	1.85	1.80	1.89	1.90	1.87	2.01	1.72	
125	1.10	1.12	1.07	1.01	1.01	1.03	1.10	1.18	1.16	
130	7.54	7.40	7.05	6.51	6.31	6.65	7.23	7.78	8.15	- 9

AP =132.0   F107 = 70.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

SEPTEMBER — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	225	224	222	216	215	220	215	216	222
75	216	216	213	205	200	207	205	204	206
80	208	206	204	198	191	198	197	191	192
85	196	198	195	191	186	190	189	183	181
90	184	193	187	183	185	181	181	181	175
95	179	193	184	179	186	175	178	187	177
100	189	200	189	183	191	180	186	201	193
105	221	217	207	200	205	199	209	227	230
110	284	250	243	235	231	238	254	268	297
115	385	305	302	293	276	301	324	330	394
120	493	392	385	370	346	381	409	415	495
125	556	497	469	446	432	451	479	508	558
130	603	567	525	501	496	503	529	572	609

SEPTEMBER — PRESSURE (N/M SQ)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	3.97	4.30	4.81	5.49	5.59	5.57	5.24	5.03	4.78	+ 0
75	1.86	2.02	2.23	2.49	2.50	2.54	2.36	2.27	2.18	
80	0.84	0.92	1.00	1.09	1.07	1.12	1.03	0.97	0.94	
85	3.70	4.01	4.35	4.63	4.43	4.75	4.35	3.99	3.86	- 1
90	1.54	1.71	1.82	1.91	1.81	1.94	1.77	1.60	1.51	
95	6.19	7.28	7.50	7.69	7.45	7.70	7.09	6.52	5.88	- 2
100	2.54	3.18	3.13	3.12	3.14	3.07	2.89	2.81	2.42	
105	1.15	1.47	1.39	1.34	1.39	1.30	1.27	1.32	1.12	
110	6.07	7.41	6.83	6.47	6.69	6.27	6.36	6.89	6.07	- 3
115	3.78	4.18	3.84	3.58	3.61	3.51	3.69	4.05	3.84	
120	2.66	2.67	2.46	2.26	2.21	2.25	2.42	2.66	2.70	
125	1.99	1.89	1.73	1.57	1.51	1.57	1.73	1.90	2.01	
130	1.52	1.42	1.29	1.16	1.11	1.16	1.29	1.43	1.54	

SEPTEMBER — DENSITY (KG/M CU)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	6.14	6.67	7.54	8.84	9.08	8.83	8.49	8.09	7.50	- 5
75	2.99	3.24	3.65	4.21	4.35	4.28	4.02	3.88	3.69	
80	1.42	1.54	1.71	1.91	1.95	1.96	1.82	1.77	1.71	
85	6.59	7.07	7.78	8.45	8.27	8.71	8.01	7.59	7.42	- 6
90	2.92	3.09	3.39	3.62	3.41	3.74	3.40	3.07	3.01	
95	1.20	1.31	1.41	1.48	1.39	1.52	1.37	1.21	1.15	
100	4.62	5.45	5.66	5.82	5.61	5.83	5.32	4.80	4.31	- 7
105	1.78	2.30	2.26	2.26	2.28	2.21	2.05	1.98	1.66	
110	7.22	9.96	9.31	9.06	9.56	8.70	8.31	8.65	6.93	- 8
115	3.29	4.54	4.13	3.94	4.21	3.76	3.71	4.08	3.26	
120	1.79	2.23	2.04	1.93	2.01	1.86	1.90	2.10	1.82	
125	1.18	1.23	1.16	1.09	1.08	1.08	1.14	1.22	1.20	
130	8.28	8.06	7.63	7.06	6.78	7.05	7.60	8.08	8.35	- 9

OCTOBER — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	226	226	223	218	212	217	217	223	231
75	213	213	210	204	200	206	209	215	222
80	199	199	198	196	194	199	204	208	212
85	184	185	189	191	190	190	196	200	201
90	172	178	183	188	189	181	186	193	190
95	171	179	182	187	189	176	180	192	187
100	185	192	191	191	194	181	185	199	197
105	223	221	212	205	206	201	207	219	225
110	296	271	251	233	230	242	251	257	280
115	409	347	313	281	274	306	322	321	366
120	518	438	395	355	344	384	407	410	467
125	570	520	476	442	431	450	474	501	543
130	615	578	534	506	496	500	520	561	597

OCTOBER — PRESSURE (N/M SQ)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	5.28	5.31	5.42	5.67	5.57	5.55	4.87	4.11	3.56	+ 0
75	2.47	2.48	2.50	2.57	2.47	2.52	2.22	1.91	1.70	
80	1.10	1.11	1.10	1.12	1.06	1.11	0.99	0.87	0.79	
85	4.59	4.64	4.67	4.72	4.46	4.72	4.30	3.85	3.52	- 1
90	1.80	1.85	1.91	1.97	1.86	1.93	1.80	1.65	1.50	
95	6.82	7.33	7.72	8.17	7.82	7.67	7.34	7.02	6.26	- 2
100	2.70	3.02	3.21	3.45	3.35	3.07	3.01	3.04	2.66	
105	1.21	1.37	1.44	1.53	1.49	1.32	1.32	1.40	1.23	
110	6.45	7.13	7.19	7.36	7.19	6.42	6.59	7.18	6.53	- 3
115	4.10	4.26	4.11	4.00	3.86	3.64	3.83	4.16	4.00	
120	2.93	2.85	2.65	2.47	2.36	2.35	2.52	2.72	2.76	
125	2.20	2.07	1.87	1.70	1.61	1.65	1.80	1.95	2.04	
130	1.69	1.56	1.39	1.25	1.18	1.22	1.34	1.47	1.55	

OCTOBER — DENSITY (KG/M CU)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	8.13	8.19	8.47	9.09	9.17	8.90	7.82	6.42	5.36	- 5
75	4.03	4.05	4.16	4.38	4.31	4.26	3.71	3.10	2.67	
80	1.92	1.94	1.94	1.99	1.91	1.94	1.69	1.46	1.29	
85	8.71	8.70	8.61	8.62	8.16	8.62	7.66	6.70	6.12	- 6
90	3.64	3.62	3.63	3.64	3.42	3.71	3.38	2.97	2.75	
95	1.39	1.42	1.47	1.51	1.43	1.51	1.41	1.27	1.16	
100	5.02	5.41	5.77	6.16	5.89	5.80	5.54	5.26	4.67	- 7
105	1.85	2.11	2.29	2.51	2.44	2.20	2.15	2.18	1.87	
110	0.74	0.88	0.95	1.04	1.03	0.87	0.87	0.93	0.79	
115	3.35	4.07	4.28	4.58	4.53	3.82	3.85	4.28	3.66	- 8
120	1.88	2.14	2.15	2.19	2.15	1.92	1.97	2.16	1.96	
125	1.28	1.29	1.24	1.19	1.15	1.13	1.19	1.25	1.24	
130	9.03	8.71	8.17	7.56	7.20	7.42	7.98	8.36	8.53	- 9

NOVEMBER							TEMPERATURE (K)		
70	225	221	217	217	212	215	221	229	230
75	204	203	202	203	199	205	213	221	224
80	184	184	191	196	193	199	210	213	217
85	169	172	183	192	190	193	204	207	209
90	162	170	181	189	189	184	195	204	202
95	167	178	184	188	190	179	189	204	199
100	187	199	195	192	196	183	190	208	206
105	230	233	218	206	209	202	205	220	228
110	305	282	256	234	234	240	240	245	269
115	411	350	316	284	278	302	299	293	337
120	511	433	396	359	346	378	381	375	429
125	569	519	477	443	429	443	459	480	522
130	621	585	538	506	493	493	509	547	584

DECEMBER							TEMPERATURE (K)		
70	225	219	213	215	215	216	220	230	232
75	199	195	195	201	200	203	214	223	225
80	176	174	182	194	193	198	213	216	218
85	159	163	176	189	188	193	208	210	210
90	152	163	178	185	184	185	199	204	202
95	158	175	186	184	182	180	190	201	200
100	181	200	202	191	189	183	189	204	207
105	232	240	227	208	206	200	202	217	228
110	326	296	263	241	240	237	234	246	268
115	459	366	317	295	294	298	291	299	334
120	558	444	390	369	364	373	372	382	424
125	582	522	474	445	433	438	452	479	515
130	622	586	538	504	490	487	501	539	575

NOVEMBER							PRESSURE (N/M SQ)			
70	7.24	6.70	6.07	5.76	5.49	5.39	4.46	3.68	3.11	+ 0
75	3.32	3.04	2.74	2.60	2.44	2.43	2.07	1.75	1.49	
80	1.40	1.28	1.17	1.13	1.04	1.07	0.94	0.81	0.70	
85	5.43	5.00	4.79	4.77	4.35	4.57	4.21	3.66	3.19	- 1
90	1.97	1.88	1.92	2.00	1.81	1.90	1.84	1.63	1.42	
95	7.17	7.25	7.76	8.34	7.61	7.68	7.80	7.30	6.25	- 2
100	2.82	3.02	3.26	3.53	3.27	3.12	3.30	3.32	2.80	
105	1.28	1.42	1.48	1.56	1.48	1.35	1.46	1.57	1.33	
110	6.94	7.55	7.49	7.54	7.20	6.58	7.18	7.93	7.00	- 3
115	4.42	4.54	4.29	4.10	3.91	3.71	4.03	4.42	4.16	
120	3.13	3.02	2.76	2.54	2.40	2.38	2.58	2.78	2.77	
125	2.34	2.17	1.94	1.75	1.63	1.67	1.82	1.95	2.01	
130	1.79	1.64	1.44	1.28	1.19	1.23	1.35	1.46	1.52	

DECEMBER							PRESSURE (N/M SQ)			
70	8.64	7.59	6.36	5.77	5.54	5.44	4.35	3.50	2.95	+ 0
75	3.92	3.38	2.81	2.58	2.47	2.45	2.02	1.67	1.42	
80	1.60	1.37	1.16	1.11	1.06	1.07	0.92	0.78	0.67	
85	5.88	5.05	4.57	4.65	4.43	4.57	4.19	3.57	3.07	- 1
90	2.00	1.81	1.78	1.92	1.82	1.90	1.86	1.60	1.37	
95	6.83	6.74	7.18	7.86	7.40	7.72	8.00	7.12	6.05	- 2
100	2.56	2.79	3.08	3.29	3.07	3.14	3.39	3.19	2.72	
105	1.15	1.33	1.44	1.46	1.35	1.35	1.49	1.49	1.30	
110	6.38	7.25	7.47	7.12	6.60	6.53	7.21	7.50	6.84	- 3
115	4.22	4.45	4.30	3.95	3.67	3.65	3.99	4.22	4.06	
120	3.10	3.00	2.75	2.48	2.31	2.32	2.53	2.69	2.70	
125	2.34	2.16	1.92	1.71	1.59	1.62	1.77	1.89	1.95	
130	1.80	1.63	1.42	1.25	1.16	1.18	1.31	1.42	1.47	

NOVEMBER							DENSITY (KG/M CU)			
70	1.12	1.06	0.97	0.93	0.90	0.87	0.70	0.56	0.47	- 4
75	5.66	5.23	4.72	4.46	4.26	4.14	3.37	2.76	2.32	- 5
80	2.65	2.43	2.13	2.00	1.98	1.96	1.56	1.32	1.12	
85	1.12	1.01	0.91	0.87	0.80	0.82	0.72	0.62	0.53	
90	4.24	3.86	3.70	3.68	3.34	3.58	3.27	2.78	2.45	- 6
95	1.49	1.41	1.46	1.53	1.38	1.48	1.43	1.24	1.09	
100	5.18	5.24	5.74	6.29	5.70	5.81	5.94	5.48	4.66	- 7
105	1.90	2.08	2.30	2.56	2.37	2.24	2.40	2.42	1.99	
110	0.77	0.90	0.97	1.06	1.01	0.90	0.99	1.08	0.88	
115	3.62	4.32	4.45	4.67	4.52	3.94	4.35	4.97	4.13	- 8
120	2.05	2.30	2.26	2.24	2.18	1.98	2.15	2.41	2.14	
125	1.36	1.37	1.30	1.23	1.18	1.16	1.23	1.30	1.27	
130	9.53	9.10	8.45	7.79	7.36	7.54	8.13	8.46	8.55	- 9

DECEMBER							DENSITY (KG/M CU)			
70	1.34	1.21	1.04	0.94	0.90	0.88	0.69	0.53	0.44	- 4
75	6.86	6.04	5.00	4.47	4.30	4.20	3.28	2.62	2.20	- 5
80	3.17	2.73	2.21	1.99	1.91	1.87	1.51	1.26	1.07	
85	1.29	1.08	0.90	0.86	0.82	0.82	0.70	0.59	0.51	
90	4.58	3.86	3.49	3.60	3.44	3.57	3.25	2.73	2.36	- 6
95	1.50	1.34	1.34	1.47	1.40	1.48	1.45	1.23	1.05	
100	4.87	4.80	5.24	5.90	5.56	5.86	6.13	5.38	4.52	- 7
105	1.69	1.88	2.16	2.36	2.20	2.27	2.49	2.33	1.94	
110	0.66	0.83	0.95	0.98	0.90	0.91	1.02	1.02	0.86	
115	3.09	4.07	4.47	4.34	4.02	3.94	4.43	4.65	4.07	- 8
120	1.86	2.24	2.29	2.14	2.00	1.96	2.15	2.28	2.11	
125	1.34	1.36	1.30	1.20	1.14	1.14	1.22	1.27	1.25	
130	9.57	9.08	8.37	7.63	7.22	7.39	8.00	9.32	8.38	- 9

AP = 4.0 F107 =150.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

JANUARY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	226	220	213	216	219	219	220	224	228
75	200	196	198	204	203	207	215	221	221
80	177	177	187	198	195	200	211	217	214
85	161	166	181	193	189	192	206	212	204
90	153	164	179	185	182	183	197	205	195
95	156	172	182	181	179	178	189	198	190
100	174	189	192	184	183	181	188	195	194
105	213	219	213	201	201	199	197	200	209
110	280	263	248	237	238	234	221	219	240
115	370	320	300	295	297	293	268	259	291
120	446	388	372	374	375	370	341	328	360
125	488	462	452	455	454	445	426	419	434
130	548	533	523	524	522	508	492	490	497

JANUARY — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	8.71	7.73	6.24	5.66	5.67	5.43	4.54	3.88	3.47	+ 0
75	3.96	3.45	2.76	2.55	2.56	2.48	2.11	1.83	1.65	
80	1.63	1.41	1.16	1.11	1.11	1.09	0.96	0.85	0.76	
85	6.02	5.28	4.68	4.76	4.68	4.67	4.34	3.92	3.44	- 1
90	2.07	1.91	1.85	1.98	1.91	1.93	1.91	1.77	1.49	
95	7.03	7.10	7.40	8.03	7.67	7.72	8.15	7.84	6.34	- 2
100	2.57	2.84	3.08	3.27	3.10	3.11	3.43	3.43	2.71	
105	1.09	1.28	1.38	1.40	1.34	1.32	1.48	1.52	1.22	
110	5.63	6.52	6.85	6.73	6.44	6.35	6.94	7.13	6.03	- 3
115	3.44	3.77	3.84	3.72	3.58	3.52	3.68	3.71	3.36	
120	2.34	2.42	2.42	2.35	2.27	2.23	2.24	2.21	2.11	
125	1.68	1.69	1.67	1.63	1.59	1.56	1.53	1.49	1.46	
130	1.25	1.25	1.23	1.21	1.18	1.15	1.12	1.09	1.07	

JANUARY — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	1.34	1.23	1.02	0.91	0.90	0.87	0.72	0.60	0.53	- 4
75	6.91	6.13	4.86	4.35	4.39	4.17	3.41	2.88	2.60	- 5
80	3.20	2.77	2.15	1.96	1.98	1.90	1.59	1.37	1.24	
85	1.30	1.11	0.90	0.86	0.86	0.85	0.73	0.64	0.59	
90	4.70	4.06	3.61	3.71	3.65	3.66	3.36	3.00	2.66	- 6
95	1.56	1.43	1.41	1.53	1.48	1.50	1.49	1.36	1.15	
100	5.06	5.14	5.47	6.05	5.78	5.85	6.24	6.00	4.77	- 7
105	1.74	1.97	2.18	2.34	2.23	2.24	2.53	2.55	1.96	
110	0.67	0.82	0.91	0.94	0.89	0.89	1.03	1.07	0.82	
115	3.04	3.84	4.14	4.06	3.88	3.84	4.38	4.60	3.71	- 8
120	1.70	2.00	2.07	1.98	1.91	1.89	2.05	2.11	1.85	
125	1.10	1.16	1.16	1.12	1.08	1.07	1.10	1.09	1.04	
130	7.21	7.30	7.28	7.08	6.88	6.84	6.85	6.71	6.54	- 9

FEBRUARY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	223	217	213	218	217	218	221	227	232
75	199	196	200	205	203	207	214	222	222
80	180	179	189	196	194	199	209	218	214
85	166	170	181	188	188	190	200	210	201
90	160	170	176	180	184	182	190	199	187
95	164	178	177	176	182	178	183	190	179
100	181	194	188	181	187	183	185	188	183
105	215	221	211	201	201	199	198	198	202
110	274	258	251	240	230	232	229	223	242
115	352	309	310	303	281	286	282	272	306
120	426	376	382	383	358	362	357	346	383
125	480	456	455	459	450	446	437	433	450
130	542	529	521	525	526	514	501	501	510

FEBRUARY — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	7.06	6.58	5.86	5.71	5.74	5.55	4.61	3.99	3.89	+ 0
75	3.19	2.93	2.61	2.59	2.59	2.53	2.14	1.90	1.86	
80	1.31	1.20	1.11	1.13	1.12	1.11	0.97	0.89	0.87	
85	4.98	4.60	4.50	4.74	4.68	4.73	4.32	4.08	3.87	- 1
90	1.79	1.72	1.77	1.93	1.92	1.94	1.84	1.81	1.64	
95	6.40	6.61	6.94	7.62	7.81	7.76	7.63	7.77	6.65	- 2
100	2.45	2.73	2.83	3.04	3.23	3.14	3.14	3.28	2.69	
105	1.07	1.25	1.25	1.30	1.40	1.35	1.35	1.42	1.16	
110	5.55	6.39	6.27	6.27	6.70	6.43	6.43	6.65	5.66	- 3
115	3.34	3.66	3.58	3.52	3.63	3.52	3.50	3.54	3.21	
120	2.24	2.32	2.30	2.26	2.25	2.21	2.18	2.16	2.07	
125	1.60	1.61	1.61	1.59	1.56	1.53	1.51	1.48	1.45	
130	1.19	1.19	1.19	1.18	1.16	1.14	1.11	1.09	1.07	

FEBRUARY — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	1.10	1.06	0.96	0.91	0.92	0.89	0.73	0.61	0.58	- 4
75	5.59	5.19	4.54	4.40	4.45	4.25	3.47	2.97	2.92	- 5
80	2.55	2.33	2.04	2.00	2.01	1.96	1.62	1.42	1.41	
85	1.04	0.94	0.87	0.88	0.87	0.87	0.75	0.68	0.67	
90	3.88	3.52	3.50	3.72	3.63	3.70	3.37	3.16	3.05	- 6
95	1.35	1.29	1.35	1.50	1.48	1.50	1.44	1.41	1.28	
100	4.65	4.81	5.14	5.73	5.89	5.86	5.81	5.95	5.03	- 7
105	1.68	1.91	1.99	2.17	2.34	2.27	2.28	2.41	1.93	
110	6.72	8.20	8.23	8.60	9.55	9.10	9.20	9.80	7.68	- 8
115	3.09	3.84	3.73	3.74	4.15	3.94	3.97	4.19	3.37	
120	1.69	1.97	1.90	1.86	1.97	1.91	1.91	1.96	1.71	
125	1.06	1.11	1.10	1.07	1.07	1.06	1.06	1.05	1.00	
130	6.87	6.98	7.01	6.85	6.69	6.68	6.71	6.59	6.42	- 9

MARCH								TEMPERATURE (K)	
70	224	218	214	220	217	220	222	224	221
75	209	205	204	206	203	208	212	217	215
80	195	193	197	197	193	196	201	207	208
85	182	184	187	187	186	187	191	197	197
90	174	180	178	176	182	180	184	191	183
95	174	183	175	171	181	178	183	189	177
100	186	194	182	176	186	184	189	194	183
105	215	214	203	197	202	201	204	207	208
110	267	247	245	240	231	233	232	232	258
115	339	298	310	309	282	287	281	277	333
120	413	368	388	392	359	363	354	349	412
125	472	450	456	463	452	450	441	441	469
130	533	521	516	524	529	522	512	516	526

APRIL								TEMPERATURE (K)	
70	233	226	218	213	212	219	222	224	225
75	225	218	209	206	201	205	208	212	213
80	215	210	202	198	194	194	195	198	198
85	200	200	192	188	191	187	184	184	182
90	187	191	181	177	187	184	178	175	169
95	190	187	175	171	186	185	178	174	166
100	186	190	179	175	188	190	187	184	179
105	207	205	200	196	199	203	205	207	210
110	249	237	241	238	225	227	238	247	269
115	314	289	306	307	272	272	290	308	353
120	390	362	384	389	349	347	364	384	433
125	457	443	451	459	449	446	449	460	483
130	519	509	507	519	529	527	521	528	541

MARCH								PRESSURE (N/M SQ)		
70	4.66	5.02	5.38	5.72	5.78	5.61	5.03	4.35	3.94	+ 0
75	2.15	2.28	2.42	2.62	2.61	2.57	2.34	2.04	1.82	
80	0.94	0.98	1.05	1.14	1.12	1.13	1.04	0.93	0.83	
85	3.36	4.06	4.43	4.82	4.67	4.73	4.45	4.06	3.64	- 1
90	1.51	1.63	1.78	1.93	1.90	1.91	1.83	1.72	1.51	
95	5.83	6.55	7.00	7.48	7.64	7.59	7.47	7.22	6.02	- 2
100	2.34	2.75	2.79	2.91	3.14	3.08	3.10	3.08	2.41	
105	1.04	1.25	1.21	1.22	1.37	1.33	1.36	1.37	1.05	
110	5.37	6.26	5.94	5.90	6.55	6.40	6.56	6.64	5.29	- 3
115	3.21	3.52	3.39	3.35	3.56	3.51	3.57	3.58	3.11	
120	2.14	2.22	2.20	2.18	2.22	2.20	2.21	2.19	2.07	
125	1.52	1.55	1.56	1.55	1.54	1.54	1.53	1.50	1.48	
130	1.14	1.15	1.16	1.16	1.15	1.14	1.13	1.11	1.10	

APRIL								PRESSURE (N/M SQ)		
70	3.49	3.89	4.86	5.58	5.63	5.64	5.63	5.35	5.00	+ 0
75	1.68	1.83	2.22	2.53	2.51	2.57	2.59	2.49	2.33	
80	0.79	0.84	0.99	1.11	1.08	1.11	1.13	1.10	1.03	
85	3.52	3.72	4.24	4.69	4.55	4.64	4.68	4.58	4.28	- 1
90	1.49	1.59	1.74	1.89	1.89	1.90	1.87	1.81	1.65	
95	6.04	6.62	6.85	7.30	7.83	7.77	7.38	7.00	6.13	- 2
100	2.47	2.79	2.72	2.84	3.27	3.26	3.01	2.79	2.35	
105	1.08	1.23	1.16	1.19	1.42	1.43	1.32	1.21	1.01	
110	5.39	6.03	5.67	5.71	6.70	6.82	6.40	5.98	5.14	- 3
115	3.11	3.34	3.23	3.23	3.57	3.64	3.53	3.37	3.09	
120	2.02	2.10	2.09	2.10	2.19	2.22	2.21	2.17	2.09	
125	1.43	1.46	1.48	1.50	1.51	1.53	1.53	1.52	1.51	
130	1.06	1.09	1.10	1.12	1.13	1.14	1.14	1.13	1.12	

MARCH								DENSITY (KG/M CU)		
70	7.26	8.03	8.74	9.06	9.29	8.38	7.39	6.76	6.21	- 5
75	3.58	3.36	4.13	4.41	4.49	4.31	3.93	3.28	2.96	
80	1.67	1.77	1.87	2.02	2.03	2.00	1.81	1.56	1.33	
85	7.37	7.67	8.23	8.97	8.75	8.82	8.12	7.17	6.45	- 6
90	3.02	3.13	3.47	3.81	3.63	3.69	3.46	3.13	2.87	
95	1.16	1.23	1.38	1.51	1.46	1.47	1.41	1.32	1.18	
100	4.30	4.35	5.25	5.64	5.75	5.71	5.61	5.43	4.51	- 7
105	1.53	1.96	1.99	2.08	2.27	2.22	2.24	2.24	1.70	
110	6.54	8.33	7.93	8.04	7.29	8.93	9.26	9.43	6.77	- 8
115	3.06	3.82	3.50	3.47	4.05	3.92	4.08	4.17	3.02	
120	1.64	1.91	1.73	1.74	1.93	1.90	1.96	1.99	1.60	
125	1.01	1.06	1.05	1.03	1.05	1.05	1.06	1.06	0.93	
130	6.57	6.71	6.73	6.67	6.57	6.62	6.67	6.57	6.42	- 9

APRIL								DENSITY (KG/M CU)		
70	5.21	6.00	7.77	8.94	9.24	8.96	8.34	8.31	7.73	- 5
75	2.60	2.92	3.70	4.29	4.35	4.36	4.33	4.09	3.61	
80	1.27	1.39	1.70	1.95	1.93	2.00	2.02	1.94	1.82	
85	6.11	6.47	7.68	8.68	8.30	8.64	8.86	8.66	8.21	- 6
90	2.77	2.89	3.34	3.71	3.51	3.58	3.64	3.59	3.37	
95	1.16	1.23	1.36	1.43	1.46	1.45	1.43	1.39	1.27	
100	4.54	5.00	5.17	5.52	5.73	5.84	5.51	5.20	4.51	- 7
105	1.76	2.01	1.95	2.03	2.39	2.37	2.16	1.98	1.62	
110	7.12	8.35	7.68	7.32	7.79	9.85	8.85	7.98	6.33	- 8
115	3.18	3.71	3.35	3.36	4.21	4.29	3.92	3.56	2.84	
120	1.63	1.82	1.70	1.68	1.96	2.01	1.91	1.79	1.54	
125	0.97	1.01	1.00	0.97	1.03	1.05	1.05	1.03	0.93	
130	6.24	6.40	6.51	6.46	6.43	6.53	6.54	6.58	6.16	- 9

AP = 4.0 F107 =150.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
MAY						TEMPERATURE (K)				
70	234	233	223	212	208	216	216	220	224	
75	229	223	213	201	196	201	199	202	203	
80	221	213	206	197	192	190	185	184	183	
85	210	205	198	191	191	185	176	171	167	
90	198	199	187	181	190	183	174	167	158	
95	191	197	181	174	188	185	178	172	160	
100	193	198	182	177	191	191	191	187	176	
105	207	206	198	195	201	205	214	214	212	
110	239	225	231	234	225	231	249	257	273	
115	291	265	287	299	271	276	301	315	357	
120	362	333	362	381	347	350	372	387	434	
125	439	424	437	452	446	446	453	462	486	
130	504	497	497	512	526	527	524	534	548	
MAY						PRESSURE (N/M SQ)				
70	2.89	3.45	4.38	5.35	5.44	5.66	5.94	6.38	6.81	+ 0
75	1.40	1.66	2.03	2.38	2.38	2.54	2.65	2.89	3.11	
80	0.67	0.77	0.92	1.03	1.01	1.08	1.11	1.21	1.31	
85	3.08	3.47	4.02	4.37	4.24	4.46	4.40	4.72	5.03	- 1
90	1.36	1.52	1.70	1.79	1.77	1.81	1.70	1.76	1.80	
95	5.82	6.62	6.93	7.10	7.44	7.38	6.61	6.60	6.32	- 2
100	2.48	2.90	2.82	2.80	3.15	3.10	2.72	2.63	2.36	
105	1.11	1.31	1.21	1.17	1.38	1.37	1.22	1.17	1.01	
110	5.47	6.27	5.77	5.58	6.50	6.57	6.09	5.89	5.17	- 3
115	3.04	3.33	3.17	3.12	3.45	3.53	3.44	3.38	3.12	
120	1.92	2.00	2.00	2.01	2.11	2.16	2.17	2.17	2.10	
125	1.33	1.36	1.39	1.42	1.45	1.49	1.51	1.51	1.51	
130	0.98	1.00	1.03	1.05	1.08	1.10	1.12	1.12	1.12	
MAY						DENSITY (KG/M CU)				
70	0.43	0.52	0.69	0.88	0.91	0.91	0.96	1.01	1.06	- 4
75	2.13	2.59	3.32	4.12	4.22	4.41	4.64	4.99	5.73	- 5
80	1.05	1.26	1.55	1.82	1.83	1.98	2.09	2.30	2.48	
85	0.51	0.59	0.71	0.80	0.77	0.84	0.87	0.96	1.05	
90	2.39	2.65	3.15	3.44	3.25	3.43	3.39	3.66	3.95	- 6
95	1.05	1.16	1.33	1.41	1.36	1.38	1.28	1.33	1.36	
100	4.40	5.01	5.27	5.40	5.63	5.53	4.87	4.82	4.59	- 7
105	1.80	2.14	2.05	2.01	2.30	2.24	1.92	1.83	1.61	
110	7.52	9.14	8.17	7.79	9.49	9.36	8.06	7.59	6.28	- 8
115	3.36	4.03	3.53	3.32	4.09	4.11	3.68	3.48	2.85	
120	1.66	1.88	1.72	1.64	1.90	1.94	1.85	1.79	1.56	
125	0.93	0.98	0.97	0.96	1.00	1.03	1.04	1.03	0.98	
130	5.89	6.05	6.18	6.18	6.21	6.37	6.54	6.53	6.43	- 9

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
JUNE						TEMPERATURE (K)				
70	233	233	224	210	207	211	210	217	224	
75	225	221	213	198	195	198	192	193	198	
80	217	212	206	194	191	191	180	174	175	
85	207	204	198	190	189	186	173	162	158	
90	199	198	189	183	187	183	173	160	149	
95	195	194	181	177	185	183	180	169	152	
100	199	195	182	179	189	189	195	188	170	
105	213	204	197	196	202	205	218	221	213	
110	243	227	230	233	231	235	253	267	289	
115	291	269	285	295	281	286	304	327	391	
120	358	337	359	373	358	361	373	394	467	
125	432	421	432	446	447	449	452	464	495	
130	496	488	490	507	522	524	524	534	549	
JUNE						PRESSURE (N/M SQ)				
70	2.64	3.34	4.19	5.22	5.25	5.48	6.02	7.25	8.21	+ 0
75	1.27	1.60	1.95	2.30	2.29	2.42	2.63	3.21	3.70	
80	0.59	0.74	0.88	0.98	0.96	1.03	1.07	1.29	1.51	
85	2.70	3.31	3.85	4.14	4.02	4.25	4.14	4.74	5.49	- 1
90	1.19	1.45	1.63	1.70	1.67	1.73	1.58	1.68	1.64	
95	5.16	6.27	6.71	6.81	6.89	7.04	6.19	6.11	6.04	- 2
100	2.25	2.72	2.73	2.72	2.88	2.92	2.58	2.42	2.15	
105	1.03	1.22	1.17	1.15	1.26	1.28	1.17	1.09	0.90	
110	5.18	5.84	5.55	5.46	6.00	6.14	5.92	5.60	4.70	- 3
115	2.90	3.12	3.04	3.03	3.25	3.34	3.36	3.27	2.94	
120	1.82	1.89	1.90	1.93	2.01	2.07	2.12	2.12	2.04	
125	1.25	1.28	1.32	1.35	1.39	1.43	1.47	1.48	1.48	
130	0.92	0.94	0.97	1.00	1.03	1.06	1.08	1.10	1.10	
JUNE						DENSITY (KG/M CU)				
70	0.39	0.50	0.65	0.87	0.88	0.91	1.00	1.16	1.28	- 4
75	1.96	2.52	3.20	4.04	4.08	4.26	4.75	5.77	6.52	- 5
80	0.95	1.21	1.49	1.76	1.76	1.87	2.07	2.58	3.00	
85	0.45	0.56	0.68	0.76	0.74	0.79	0.83	1.02	1.21	
90	2.08	2.54	3.01	3.24	3.10	3.28	3.17	3.64	4.29	- 6
95	0.91	1.11	1.28	1.33	1.28	1.33	1.19	1.25	1.39	
100	3.87	4.76	5.11	5.17	5.20	5.28	4.53	4.40	4.32	- 7
105	1.63	2.00	1.99	1.96	2.09	2.10	1.81	1.66	1.44	
110	7.00	8.45	7.91	7.67	8.55	8.62	7.72	6.95	5.42	- 8
115	3.20	3.72	3.41	3.29	3.71	3.78	3.57	3.26	2.45	
120	1.60	1.76	1.66	1.62	1.77	1.82	1.81	1.72	1.41	
125	0.90	0.93	0.93	0.93	0.96	0.99	1.02	1.01	0.95	
130	5.63	5.79	5.93	5.94	6.00	6.19	6.39	6.41	6.34	- 9

JULY								TEMPERATURE (K)	
70	230	227	220	211	211	211	209	215	224
75	220	217	210	200	198	200	194	191	197
80	211	211	205	194	191	195	184	172	174
85	203	207	199	188	186	190	178	162	159
90	196	203	191	181	182	184	177	162	151
95	194	198	185	177	181	180	180	171	154
100	200	197	186	182	186	184	192	191	172
105	217	203	197	200	203	200	214	222	211
110	248	222	225	236	235	235	250	266	279
115	296	261	275	294	290	293	304	323	373
120	362	330	347	370	366	372	375	390	449
125	434	420	428	444	450	454	453	462	489
130	497	490	491	507	522	523	522	533	547

AUGUST								TEMPERATURE (K)	
70	227	223	219	215	215	218	213	216	225
75	219	217	212	205	200	205	200	195	199
80	213	213	207	197	192	197	190	178	179
85	204	207	199	190	187	190	183	169	165
90	193	199	189	183	185	182	178	169	158
95	188	192	182	178	185	177	172	178	161
100	192	191	183	182	190	181	188	195	178
105	212	200	198	198	202	199	209	221	213
110	252	225	231	231	229	235	247	257	273
115	313	271	286	287	276	294	305	307	353
120	386	344	362	364	351	375	379	375	428
125	450	432	437	446	447	456	454	455	481
130	509	501	500	514	525	524	521	529	542

JULY							PRESSURE (N/M SQ)			
70	2.74	3.46	4.30	5.15	5.29	5.31	5.75	7.16	8.30	+ 0
75	1.30	1.63	1.98	2.28	2.34	2.35	2.50	3.13	3.74	
80	0.60	0.75	0.88	0.98	0.99	1.01	1.03	1.24	1.51	
85	2.67	3.37	3.87	4.10	4.10	4.28	4.11	4.55	5.51	- 1
90	1.16	1.50	1.66	1.67	1.67	1.76	1.61	1.62	1.87	
95	4.97	6.58	6.91	6.64	6.73	7.12	6.36	5.98	6.24	- 2
100	2.18	2.89	2.87	2.67	2.76	2.89	2.63	2.40	2.25	
105	1.01	1.29	1.24	1.14	1.20	1.24	1.18	1.09	0.95	
110	5.10	6.09	5.82	5.49	5.76	5.90	5.87	5.61	4.87	- 3
115	2.88	3.19	3.13	3.05	3.17	3.24	3.31	3.27	2.98	
120	1.82	1.91	1.92	1.93	1.98	2.04	2.10	2.10	2.04	
125	1.26	1.29	1.32	1.34	1.38	1.42	1.45	1.47	1.46	
130	0.92	0.94	0.97	0.99	1.02	1.05	1.07	1.08	1.09	

AUGUST							PRESSURE (N/M SQ)			
70	3.02	3.83	4.43	5.28	5.49	5.46	5.51	6.34	7.03	+ 0
75	1.43	1.79	2.04	2.38	2.46	2.48	2.46	2.80	3.19	
80	0.66	0.82	0.92	1.04	1.05	1.08	1.04	1.14	1.31	
85	2.95	3.73	4.07	4.41	4.36	4.58	4.27	4.33	4.94	- 1
90	1.28	1.65	1.73	1.81	1.79	1.87	1.70	1.61	1.75	
95	5.36	7.08	7.08	7.27	7.35	7.47	6.71	6.19	6.18	- 2
100	2.27	3.01	2.89	2.94	3.07	2.99	2.73	2.56	2.33	
105	1.02	1.32	1.24	1.25	1.35	1.27	1.20	1.17	1.00	
110	5.15	6.23	5.90	5.97	6.40	6.04	5.94	5.98	5.14	- 3
115	2.97	3.32	3.23	3.27	3.43	3.33	3.35	3.41	3.09	
120	1.93	2.02	2.03	2.05	2.10	2.10	2.14	2.15	2.08	
125	1.36	1.38	1.41	1.43	1.45	1.47	1.49	1.49	1.48	
130	1.00	1.02	1.04	1.06	1.08	1.09	1.10	1.10	1.10	

JULY							DENSITY (KG/M CU)			
70	0.41	0.53	0.68	0.85	0.87	0.87	0.96	1.16	1.29	- 4
75	2.06	2.61	3.27	3.98	4.12	4.09	4.50	5.73	6.62	- 5
80	0.99	1.23	1.50	1.76	1.81	1.81	1.96	2.52	3.02	
85	0.46	0.57	0.68	0.76	0.77	0.78	0.80	0.98	1.21	
90	2.05	2.57	3.01	3.20	3.18	3.33	3.17	3.48	4.30	- 6
95	0.88	1.15	1.29	1.29	1.29	1.37	1.22	1.21	1.40	
100	3.71	5.02	5.27	5.01	5.07	5.37	4.69	4.31	4.49	- 7
105	1.56	2.14	2.10	1.92	1.99	2.07	1.85	1.65	1.52	
110	6.77	9.04	8.48	7.64	8.06	8.27	7.76	7.00	5.80	- 8
115	3.13	3.93	3.64	3.32	3.52	3.57	3.53	3.30	2.62	
120	1.59	1.82	1.73	1.64	1.71	1.73	1.78	1.73	1.46	
125	0.90	0.94	0.94	0.93	0.95	0.97	1.01	1.01	0.96	
130	5.65	5.80	5.92	5.93	5.97	6.16	6.34	6.36	6.28	- 9

AUGUST							DENSITY (KG/M CU)			
70	0.46	0.60	0.70	0.86	0.89	0.87	0.90	1.02	1.09	- 4
75	2.27	2.87	3.35	4.06	4.27	4.21	4.27	5.02	5.57	- 5
80	1.08	1.34	1.55	1.83	1.91	1.91	1.91	2.23	2.55	
85	0.50	0.63	[illegible]	0.81	0.81	0.84	0.81	0.89	1.04	
90	2.29	2.88	3.18	3.45	3.36	3.58	3.32	3.31	3.85	- 6
95	0.99	1.28	1.35	1.41	1.37	1.46	1.30	1.20	1.32	
100	4.03	5.40	5.39	5.51	5.53	5.64	4.98	4.50	4.48	- 7
105	1.62	2.21	2.10	2.12	2.23	2.15	1.94	1.79	1.59	
110	6.73	9.12	8.38	8.47	9.22	8.47	7.94	7.70	6.27	- 8
115	3.06	3.93	3.61	3.65	4.01	3.64	3.56	3.60	2.86	
120	1.58	1.85	1.75	1.77	1.88	1.77	1.79	1.84	1.56	
125	0.93	0.99	0.98	0.98	1.00	1.00	1.02	1.03	0.98	
130	6.00	6.15	6.26	6.23	6.22	6.36	6.50	6.47	6.37	- 9

NOVEMBER TEMPERATURE (K)

70	225	221	217	217	212	215	221	229	230
75	204	203	202	203	199	205	213	221	224
80	184	184	191	196	193	199	210	213	217
85	169	172	184	192	190	193	205	207	209
90	161	169	181	189	189	185	196	204	201
95	165	177	183	188	191	179	188	202	197
100	182	194	193	192	197	183	188	203	200
105	217	222	213	205	210	201	201	211	215
110	276	263	247	233	236	239	231	229	246
115	354	316	300	293	292	300	284	267	296
120	429	393	373	358	354	377	358	334	364
125	483	460	454	450	447	450	435	424	439
130	548	534	524	527	526	512	497	496	504

NOVEMBER PRESSURE (N/M SQ)

70	7.24	6.70	6.07	5.76	5.49	5.39	4.46	3.68	3.11	+ 0
75	3.32	3.04	2.73	2.60	2.44	2.43	2.07	1.75	1.49	
80	1.40	1.28	1.17	1.13	1.04	1.07	0.74	0.81	0.70	
85	5.41	5.00	4.79	4.78	4.36	4.57	4.21	3.66	3.19	- 1
90	1.96	1.87	1.92	2.00	1.81	1.90	1.84	1.63	1.42	
95	7.05	7.16	7.73	8.35	7.63	7.69	7.79	7.24	6.17	- 2
100	2.70	2.94	3.22	3.53	3.29	3.12	3.27	3.25	2.71	
105	1.19	1.34	1.44	1.56	1.49	1.35	1.43	1.50	1.25	
110	6.13	6.91	7.17	7.49	7.28	6.54	6.85	7.28	6.29	- 3
115	3.59	3.98	4.03	4.06	3.97	3.68	3.76	3.89	3.55	
120	2.47	2.55	2.54	2.51	2.46	2.36	2.35	2.35	2.25	
125	1.77	1.77	1.77	1.74	1.70	1.66	1.63	1.59	1.56	
130	1.31	1.31	1.31	1.29	1.26	1.24	1.21	1.17	1.15	

NOVEMBER DENSITY (KG/M CU)

70	1.12	1.06	0.97	0.93	0.90	0.87	0.70	0.56	0.47	- 4
75	5.66	5.23	4.72	4.45	4.25	4.14	3.37	2.75	2.32	- 5
80	2.65	2.42	2.13	2.00	1.33	1.86	1.56	1.32	1.12	
85	1.12	1.01	0.91	0.86	0.30	0.82	0.72	0.61	0.53	
90	4.23	3.35	3.69	3.67	3.33	3.57	3.27	2.78	2.45	- 6
95	1.43	1.40	1.46	1.53	1.33	1.43	1.43	1.24	1.08	
100	5.09	5.19	5.72	6.28	5.70	5.81	5.93	5.45	4.62	- 7
105	1.34	2.04	2.28	2.55	2.37	2.24	2.38	2.33	1.95	
110	0.74	0.87	0.96	1.06	1.01	0.89	0.97	1.04	0.34	
115	3.10	1.10	1.32	1.62	1.52	3.91	4.21	4.66	3.84	- 8
120	1.36	2.12	2.15	2.21	2.17	1.95	2.24	2.20	1.93	
125	1.15	1.21	1.21	1.19	1.17	1.13	1.14	1.15	1.09	
130	7.52	7.54	7.45	7.15	7.27	7.24	7.25	7.09	6.90	- 9

DECEMBER TEMPERATURE (K)

70	225	219	213	215	215	216	220	230	232
75	199	195	195	201	200	203	214	223	225
80	176	174	183	194	193	198	213	216	219
85	159	163	177	189	188	193	209	210	210
90	151	162	178	186	184	186	199	204	202
95	156	173	185	185	183	180	190	199	197
100	176	195	200	191	189	183	187	199	201
105	219	229	221	207	207	200	198	208	215
110	293	274	254	240	242	236	226	230	245
115	389	329	301	294	298	296	277	272	293
120	460	392	368	369	373	372	350	339	359
125	493	463	450	452	453	445	429	422	432
130	550	535	524	525	522	507	490	488	495

DECEMBER PRESSURE (N/M SQ)

70	8.64	7.59	6.36	5.77	5.54	5.44	4.35	3.50	2.95	+ 0
75	3.91	3.38	2.81	2.58	2.47	2.45	2.02	1.67	1.42	
80	1.60	1.37	1.16	1.11	1.06	1.07	0.92	0.78	0.67	
85	5.86	5.04	4.57	4.66	4.43	4.57	4.20	3.57	3.07	- 1
90	1.99	1.80	1.78	1.92	1.82	1.91	1.86	1.60	1.37	
95	6.70	6.66	7.15	7.87	7.42	7.74	7.99	7.07	5.98	- 2
100	2.46	2.72	3.05	3.28	3.09	3.14	3.36	3.12	2.64	
105	1.06	1.26	1.41	1.45	1.36	1.35	1.45	1.42	1.22	
110	5.62	6.61	7.14	7.06	6.66	6.50	6.87	6.83	6.15	- 3
115	3.51	3.90	4.03	3.91	3.73	3.62	3.71	3.71	3.46	
120	2.43	2.52	2.53	2.45	2.37	2.30	2.29	2.26	2.18	
125	1.75	1.76	1.74	1.70	1.65	1.61	1.58	1.54	1.51	
130	1.30	1.30	1.28	1.26	1.23	1.19	1.16	1.13	1.11	

DECEMBER DENSITY (KG/M CU)

70	1.34	1.21	1.04	0.94	0.90	0.88	0.69	0.53	0.44	- 4
75	6.86	6.03	5.00	4.47	4.30	4.20	3.27	2.61	2.19	- 5
80	3.17	2.73	2.21	1.99	1.91	1.87	1.51	1.26	1.06	
85	1.28	1.08	0.90	0.86	0.82	0.82	0.70	0.59	0.51	
90	4.57	3.85	3.49	3.59	3.43	3.56	3.25	2.73	2.35	- 6
95	1.49	1.33	1.33	1.47	1.40	1.48	1.45	1.23	1.05	
100	4.78	4.76	5.22	5.89	5.55	5.86	6.12	5.35	4.43	- 7
105	1.64	1.85	2.14	2.35	2.20	2.26	2.16	2.29	1.90	
110	6.36	7.99	9.31	9.70	9.05	9.01	9.76	9.30	8.24	- 8
115	2.95	3.36	4.34	4.29	4.02	3.91	4.27	4.36	3.77	
120	1.70	2.05	2.19	2.10	1.99	1.93	2.04	2.03	1.90	
125	1.14	1.20	1.21	1.17	1.13	1.11	1.12	1.12	1.07	
130	7.19	7.53	7.57	7.35	7.13	7.09	7.09	6.94	6.75	- 9

NOVEMBER						TEMPERATURE (K)			
70	225	221	217	217	212	215	221	229	230
75	204	203	202	203	199	205	213	221	224
80	184	184	191	196	193	199	210	213	217
85	169	172	184	192	190	193	205	207	209
90	161	169	181	189	189	185	196	204	201
95	165	177	183	188	191	179	198	202	197
100	182	194	193	192	197	183	198	203	200
105	217	222	213	205	210	201	201	211	215
110	276	263	247	233	236	239	231	229	246
115	354	316	300	283	282	300	284	267	296
120	428	383	373	358	354	377	358	334	364
125	483	460	454	450	447	450	435	424	439
130	548	534	524	527	526	512	497	496	504

NOVEMBER						PRESSURE (N/M SQ)				
70	7.24	6.70	6.07	5.76	5.49	5.39	4.46	3.68	3.11	+ 0
75	3.32	3.04	2.73	2.60	2.44	2.43	2.07	1.75	1.49	
80	1.40	1.28	1.17	1.13	1.04	1.07	0.94	0.81	0.70	
85	5.41	5.00	4.79	4.78	4.36	4.57	4.21	3.66	3.19	- 1
90	1.96	1.87	1.92	2.00	1.81	1.90	1.84	1.63	1.42	
95	7.05	7.16	7.73	8.35	7.63	7.69	7.79	7.24	6.17	- 2
100	2.70	2.94	3.22	3.53	3.29	3.12	3.27	3.25	2.71	
105	1.19	1.34	1.44	1.56	1.49	1.35	1.43	1.50	1.25	
110	6.13	6.91	7.17	7.49	7.28	6.54	6.85	7.28	6.29	- 3
115	3.69	3.98	4.03	4.06	3.97	3.68	3.76	3.89	3.55	
120	2.47	2.55	2.54	2.51	2.46	2.36	2.35	2.35	2.25	
125	1.77	1.77	1.77	1.74	1.70	1.66	1.63	1.59	1.56	
130	1.31	1.31	1.31	1.29	1.26	1.24	1.21	1.17	1.15	

NOVEMBER						DENSITY (KG/M CU)				
70	1.12	1.06	0.97	0.93	0.90	0.87	0.70	0.56	0.47	- 4
75	5.66	5.23	4.72	4.45	4.25	4.14	3.37	2.75	2.32	- 5
80	2.55	2.42	2.13	2.00	1.88	1.86	1.56	1.32	1.12	
85	1.12	1.01	0.91	0.86	0.80	0.82	0.72	0.61	0.53	
90	4.23	3.85	3.69	3.67	3.33	3.57	3.27	2.78	2.45	- 6
95	1.43	1.40	1.46	1.53	1.38	1.48	1.43	1.24	1.08	
100	5.09	5.19	5.72	6.28	5.70	5.81	5.93	5.45	4.62	- 7
105	1.84	2.04	2.28	2.55	2.37	2.24	2.38	2.38	1.95	
110	0.74	0.87	0.96	1.06	1.01	0.89	0.97	1.04	0.94	
115	3.40	4.10	4.32	4.62	4.52	3.91	4.21	4.56	3.84	- 8
120	1.36	2.12	2.13	2.21	2.17	1.95	2.04	2.09	1.93	
125	1.15	1.21	1.21	1.19	1.17	1.13	1.14	1.15	1.09	
130	7.52	7.54	7.55	7.15	7.27	7.24	7.25	7.22	6.90	- 9

DECEMBER						TEMPERATURE (K)			
70	225	219	213	215	215	216	220	230	232
75	199	195	195	201	200	203	214	223	225
80	176	174	183	194	193	198	213	216	219
85	159	163	177	189	188	193	209	210	210
90	151	162	178	186	184	186	199	204	202
95	156	173	185	185	183	180	190	199	197
100	176	195	200	191	189	183	187	199	201
105	219	229	221	207	207	200	198	208	215
110	293	274	254	240	242	236	226	230	245
115	389	329	301	294	298	296	277	272	293
120	460	392	368	369	373	372	350	339	359
125	493	463	450	452	453	445	429	422	432
130	550	535	524	525	522	507	490	488	495

DECEMBER						PRESSURE (N/M SQ)				
70	8.64	7.59	6.36	5.77	5.54	5.44	4.35	3.50	2.95	+ 0
75	3.91	3.38	2.81	2.58	2.47	2.45	2.02	1.67	1.42	
80	1.60	1.37	1.16	1.11	1.06	1.07	0.92	0.78	0.67	
85	5.86	5.04	4.57	4.66	4.43	4.57	4.20	3.57	3.07	- 1
90	1.99	1.80	1.78	1.92	1.82	1.91	1.86	1.60	1.37	
95	6.70	6.66	7.15	7.87	7.42	7.74	7.99	7.07	5.98	- 2
100	2.46	2.72	3.05	3.28	3.08	3.14	3.36	3.12	2.64	
105	1.06	1.26	1.41	1.45	1.36	1.35	1.45	1.42	1.22	
110	5.62	6.61	7.14	7.06	6.66	6.50	6.97	6.88	6.15	- 3
115	3.51	3.90	4.03	3.91	3.73	3.62	3.71	3.71	3.46	
120	2.43	2.52	2.53	2.45	2.37	2.30	2.29	2.26	2.18	
125	1.75	1.76	1.74	1.70	1.65	1.61	1.58	1.54	1.51	
130	1.30	1.30	1.28	1.26	1.23	1.19	1.16	1.13	1.11	

DECEMBER						DENSITY (KG/M CU)				
70	1.34	1.21	1.04	0.94	0.90	0.88	0.69	0.53	0.44	- 4
75	6.86	6.03	5.09	4.47	4.30	4.20	3.27	2.61	2.19	- 5
80	3.17	2.73	2.21	1.99	1.91	1.87	1.51	1.26	1.06	
85	1.28	1.08	0.90	0.86	0.82	0.82	0.70	0.59	0.51	
90	4.57	3.85	3.43	3.59	3.43	3.56	3.25	2.73	2.35	- 6
95	1.49	1.33	1.33	1.47	1.40	1.48	1.45	1.23	1.05	
100	4.78	4.76	5.22	5.89	5.55	5.86	6.12	5.35	4.48	- 7
105	1.64	1.85	2.14	2.35	2.20	2.26	2.16	2.29	1.90	
110	6.36	7.99	9.31	9.70	9.05	9.01	9.76	9.90	8.24	- 8
115	2.95	3.36	4.34	4.29	4.02	3.91	4.27	4.36	[illegible]	
120	1.70	2.05	2.19	2.10	1.99	1.93	2.04	2.03	1.90	
125	1.14	1.20	1.21	1.17	1.13	1.11	1.12	1.12	1.07	
130	7.19	7.53	7.57	7.35	7.13	7.09	7.09	6.94	6.75	- 9

AP =132.0 F107 =150.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

JANUARY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	226	220	213	216	219	219	220	224	228
75	200	196	198	204	203	207	215	221	221
80	177	177	187	198	195	199	211	217	214
85	161	166	181	193	189	192	206	212	205
90	154	165	179	186	182	183	198	207	197
95	159	174	184	182	179	178	191	202	194
100	181	196	196	186	184	183	191	202	202
105	228	232	221	205	203	202	203	211	224
110	316	288	262	243	241	241	233	237	267
115	448	366	326	307	303	305	290	290	340
120	564	460	414	394	386	390	378	383	442
125	613	554	509	482	469	471	480	506	549
130	670	633	586	553	539	537	552	589	625

JANUARY — PRESSURE (N/M SQ)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	8.71	7.73	6.24	5.66	5.67	5.43	4.54	3.88	3.47	+ 0
75	3.97	3.46	2.76	2.55	2.56	2.48	2.11	1.83	1.65	
80	1.63	1.41	1.16	1.11	1.11	1.09	0.96	0.85	0.76	
85	6.05	5.30	4.69	4.76	4.68	4.67	4.34	3.93	3.45	- 1
90	2.09	1.93	1.86	1.98	1.92	1.93	1.91	1.78	1.51	
95	7.22	7.24	7.49	8.08	7.70	7.76	8.23	7.97	6.48	- 2
100	2.72	2.97	3.16	3.31	3.13	3.15	3.52	3.56	2.84	
105	1.21	1.38	1.45	1.44	1.36	1.36	1.56	1.64	1.33	
110	6.61	7.40	7.42	7.05	6.63	6.64	7.57	8.07	6.95	- 3
115	4.32	4.52	4.31	3.97	3.74	3.76	4.18	4.45	4.13	
120	3.16	3.07	2.82	2.56	2.41	2.44	2.66	2.81	2.78	
125	2.42	2.25	2.02	1.82	1.71	1.74	1.89	2.00	2.04	
130	1.89	1.73	1.53	1.37	1.28	1.31	1.43	1.53	1.57	

JANUARY — DENSITY (KG/M CU)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	1.34	1.23	1.02	0.91	0.90	0.87	0.72	0.60	0.53	- 4
75	6.92	6.13	4.86	4.36	4.39	4.17	3.41	2.89	2.60	- 5
80	3.20	2.77	2.16	1.96	1.98	1.90	1.59	1.37	1.24	
85	1.31	1.11	0.90	0.86	0.86	0.85	0.73	0.64	0.59	
90	4.72	4.07	3.61	3.71	3.65	3.65	3.36	3.00	2.66	- 6
95	1.57	1.44	1.41	1.54	1.48	1.50	1.49	1.37	1.16	
100	5.18	5.21	5.51	6.08	5.80	5.87	6.28	6.06	4.85	- 7
105	1.81	2.02	2.22	2.37	2.24	2.26	2.58	2.62	2.02	
110	0.71	0.86	0.94	0.96	0.90	0.90	1.07	1.13	0.88	
115	3.23	4.11	4.33	4.17	3.95	3.94	4.64	5.02	4.05	- 8
120	1.86	2.20	2.20	2.06	1.96	1.96	2.21	2.37	2.08	
125	1.30	1.33	1.26	1.18	1.12	1.13	1.22	1.26	1.22	
130	9.27	8.86	8.24	7.61	7.19	7.35	7.90	8.17	8.20	- 9

FEBRUARY — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	223	217	213	218	217	218	221	227	232
75	199	196	200	205	203	207	214	222	222
80	180	179	189	196	194	198	209	218	214
85	167	170	181	188	188	190	200	210	201
90	162	171	177	180	184	182	191	201	189
95	167	181	179	177	183	179	185	193	183
100	188	201	192	183	188	184	188	194	190
105	231	234	219	204	203	202	205	208	216
110	308	282	266	246	234	238	242	242	270
115	421	351	337	315	287	297	306	306	360
120	534	444	426	403	367	381	397	406	474
125	602	546	513	486	464	472	493	522	569
130	665	629	583	554	543	544	562	600	636

FEBRUARY — PRESSURE (N/M SQ)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	7.06	6.58	5.86	5.71	5.74	5.55	4.61	3.99	3.89	+ 0
75	3.19	2.93	2.61	2.59	2.59	2.53	2.14	1.90	1.86	
80	1.32	1.20	1.11	1.13	1.12	1.11	0.97	0.89	0.87	
85	5.00	4.61	4.51	4.75	4.68	4.74	4.32	4.09	3.89	- 1
90	1.81	1.73	1.78	1.93	1.92	1.94	1.85	1.82	1.66	
95	6.58	6.74	7.02	7.66	7.84	7.80	7.71	7.90	6.80	- 2
100	2.60	2.85	2.90	3.08	3.26	3.18	3.22	3.41	2.82	
105	1.19	1.35	1.32	1.34	1.43	1.38	1.42	1.53	1.27	
110	6.49	7.24	6.80	6.57	6.90	6.73	7.01	7.53	6.54	- 3
115	4.18	4.37	4.03	3.76	3.79	3.77	3.97	4.24	3.96	
120	3.01	2.94	2.68	2.47	2.38	2.41	2.58	2.74	2.73	
125	2.29	2.14	1.94	1.77	1.67	1.71	1.86	1.98	2.04	
130	1.78	1.65	1.48	1.34	1.26	1.29	1.41	1.52	1.58	

FEBRUARY — DENSITY (KG/M CU)

KM	-80	-60	-40	-20	0	20	40	60	80	
70	1.10	1.06	0.96	0.91	0.92	0.89	0.73	0.61	0.58	- 4
75	5.59	5.19	4.55	4.40	4.45	4.25	3.47	2.97	2.92	- 5
80	2.55	2.33	2.04	2.00	2.01	1.96	1.62	1.42	1.41	
85	1.05	0.94	0.87	0.88	0.87	0.87	0.75	0.68	0.67	
90	3.89	3.53	3.50	3.72	3.63	3.70	3.37	3.16	3.06	- 6
95	1.36	1.29	1.35	1.50	1.48	1.51	1.44	1.41	1.29	
100	4.76	4.88	5.18	5.76	5.91	5.89	5.85	6.02	5.12	- 7
105	1.75	1.96	2.03	2.20	2.36	2.29	2.33	2.49	2.00	
110	0.71	0.86	0.85	0.88	0.97	0.93	0.95	1.04	0.82	
115	3.32	4.13	3.90	3.84	4.23	4.06	4.19	4.56	3.67	- 8
120	1.87	2.17	2.02	1.93	2.03	1.98	2.05	2.19	1.91	
125	1.25	1.27	1.20	1.13	1.11	1.11	1.17	1.21	1.18	
130	8.80	8.46	7.93	7.36	7.00	7.18	7.71	8.01	8.11	- 9

MARCH TEMPERATURE (K)

70	224	218	214	220	217	220	222	224	221
75	209	205	204	206	203	208	212	217	215
80	195	193	196	197	193	196	201	207	208
85	183	184	187	187	186	187	191	197	197
90	176	182	179	177	182	180	185	192	185
95	178	186	176	172	181	179	185	193	180
100	194	200	185	178	187	186	192	200	190
105	231	226	211	200	203	204	211	218	222
110	299	270	260	247	234	239	245	252	288
115	403	337	338	322	287	297	303	311	395
120	515	433	433	413	369	381	392	407	515
125	593	540	515	490	466	476	496	528	591
130	657	621	578	553	546	551	574	615	651

MARCH PRESSURE (N/M SQ)

70	4.66	5.02	5.38	5.72	5.78	5.61	5.03	4.35	3.94	+ 0
75	2.15	2.28	2.42	2.62	2.61	2.57	2.34	2.04	1.83	
80	0.94	0.99	1.05	1.15	1.13	1.13	1.04	0.93	0.83	
85	3.88	4.07	4.43	4.82	4.67	4.73	4.46	4.07	3.65	- 1
90	1.53	1.64	1.79	1.94	1.90	1.91	1.84	1.73	1.53	
95	5.99	6.68	7.08	7.52	7.67	7.64	7.55	7.36	6.17	- 2
100	2.47	2.87	2.87	2.95	3.17	3.12	3.18	3.21	2.54	
105	1.15	1.35	1.27	1.26	1.39	1.37	1.43	1.48	1.15	
110	6.25	7.07	6.44	6.18	6.74	6.70	7.13	7.52	6.14	- 3
115	3.98	4.20	3.82	3.58	3.72	3.76	4.04	4.28	3.86	
120	2.84	2.80	2.58	2.38	2.35	2.41	2.60	2.77	2.75	
125	2.15	2.05	1.88	1.73	1.66	1.71	1.86	2.00	2.08	
130	1.68	1.58	1.44	1.31	1.25	1.30	1.42	1.54	1.62	

MARCH DENSITY (KG/M CU)

70	7.26	8.03	8.74	9.06	9.29	8.88	7.89	6.76	6.21	- 5
75	3.58	3.86	4.13	4.41	4.49	4.31	3.83	3.29	2.96	
80	1.67	1.77	1.87	2.02	2.03	2.00	1.81	1.57	1.39	
85	7.38	7.68	8.23	8.97	8.75	8.82	8.12	7.18	6.45	- 6
90	3.03	3.14	3.48	3.81	3.63	3.69	3.46	3.14	2.88	
95	1.17	1.24	1.39	1.51	1.46	1.48	1.41	1.32	1.19	
100	4.39	4.92	5.29	5.67	5.77	5.74	5.66	5.50	4.60	- 7
105	1.69	2.02	2.02	2.10	2.29	2.24	2.29	2.31	1.77	
110	7.03	8.76	8.19	8.20	9.42	9.16	9.60	9.98	7.18	- 8
115	3.29	4.11	3.66	3.56	4.13	4.04	4.30	4.54	3.26	
120	1.82	2.11	1.89	1.80	1.99	1.98	2.11	2.22	1.77	
125	1.19	1.22	1.15	1.08	1.03	1.10	1.17	1.22	1.16	
130	8.33	8.10	7.69	7.17	6.88	7.11	7.61	7.97	8.14	- 9

APRIL TEMPERATURE (K)

70	233	226	218	218	212	219	222	224	225
75	225	218	209	206	201	205	208	212	213
80	215	210	202	198	194	194	195	198	198
85	201	200	192	188	191	187	184	184	182
90	188	192	181	177	188	184	179	176	171
95	184	190	176	171	186	186	180	177	170
100	193	196	183	177	189	192	190	189	185
105	221	217	207	199	201	206	212	218	224
110	278	258	255	245	228	233	251	270	302
115	369	326	334	319	277	282	313	351	423
120	483	426	430	410	358	363	403	454	545
125	576	533	509	486	463	471	505	553	607
130	645	608	568	549	546	556	583	627	664

APRIL PRESSURE (N/M SQ)

70	3.49	3.89	4.86	5.58	5.63	5.64	5.63	5.35	5.00	+ 0
75	1.68	1.83	2.22	2.53	2.51	2.57	2.59	2.49	2.33	
80	0.79	0.84	0.99	1.11	1.08	1.11	1.13	1.10	1.03	
85	3.53	3.72	4.24	4.69	4.55	4.64	4.69	4.59	4.30	- 1
90	1.50	1.60	1.74	1.89	1.89	1.90	1.87	1.82	1.67	
95	6.19	6.74	6.93	7.34	7.86	7.81	7.47	7.14	6.29	- 2
100	2.59	2.90	2.79	2.87	3.30	3.30	3.09	2.91	2.48	
105	1.19	1.33	1.22	1.22	1.45	1.47	1.38	1.31	1.11	
110	6.24	6.81	6.16	5.97	6.90	7.14	6.95	6.76	5.99	- 3
115	3.83	3.98	3.65	3.46	3.73	3.89	3.97	4.04	3.85	
120	2.66	2.64	2.46	2.30	2.31	2.43	2.58	2.74	2.79	
125	2.00	1.93	1.81	1.67	1.62	1.70	1.85	2.02	2.13	
130	1.55	1.49	1.38	1.27	1.23	1.29	1.41	1.55	1.67	

APRIL DENSITY (KG/M CU)

70	5.21	6.00	7.77	8.94	9.24	8.96	8.84	8.31	7.73	- 5
75	2.60	2.92	3.70	4.29	4.35	4.36	4.33	4.09	3.81	
80	1.28	1.39	1.70	1.95	1.93	2.00	2.02	1.94	1.82	
85	6.12	6.47	7.69	8.68	8.30	8.64	8.86	8.67	8.22	- 6
90	2.77	2.89	3.34	3.71	3.51	3.58	3.65	3.59	3.40	
95	1.16	1.23	1.36	1.48	1.46	1.45	1.43	1.40	1.28	
100	4.62	5.06	5.22	5.54	5.95	5.87	5.56	5.28	4.62	- 7
105	1.82	2.08	1.98	2.05	2.41	2.39	2.20	2.04	1.69	
110	0.76	0.88	0.79	0.80	0.99	1.01	0.92	0.84	0.67	
115	3.45	4.00	3.51	3.45	4.29	4.43	4.12	3.91	3.04	- 8
120	1.82	2.00	1.80	1.74	2.01	2.10	2.04	1.97	1.70	
125	1.13	1.16	1.10	1.05	1.07	1.11	1.15	1.18	1.16	
130	7.84	7.73	7.43	6.94	6.72	7.02	7.52	7.96	8.22	- 9

AP =132.0 F107 =150.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
MAY					TEMPERATURE (K)					
70	234	233	223	212	208	216	216	220	224	
75	229	223	213	201	196	201	199	202	203	
80	221	213	206	197	192	190	185	184	183	
85	210	205	198	191	191	185	176	172	168	
90	200	201	188	182	190	183	174	168	160	
95	195	200	182	175	189	186	180	175	164	
100	201	204	186	178	192	193	195	193	[illegible]	
105	222	217	204	198	203	209	221	227	227	
110	266	245	244	240	228	237	264	281	307	
115	339	297	311	312	276	286	327	360	428	
120	444	389	403	402	356	367	413	457	545	
125	554	511	494	479	460	472	509	555	608	
130	631	596	558	542	543	556	587	633	670	
MAY					PRESSURE (N/M SQ)					
70	2.89	3.45	4.38	5.35	5.44	5.66	5.94	6.38	6.81	+ 0
75	1.40	1.66	2.03	2.38	2.38	2.54	2.65	2.89	3.11	
80	0.67	0.77	0.92	1.03	1.01	1.08	1.11	1.21	1.31	
85	3.09	3.47	4.03	4.37	4.24	4.46	4.41	4.74	5.05	- 1
90	1.37	1.53	1.70	1.80	1.78	1.81	1.70	1.77	1.82	
95	5.95	6.73	7.00	7.14	7.46	7.43	6.69	6.73	6.50	- 2
100	2.61	3.02	2.89	2.84	3.17	3.14	2.79	2.75	2.50	
105	1.21	1.41	1.27	1.20	1.40	1.41	1.28	1.26	1.12	
110	6.31	7.10	6.29	5.84	6.69	6.88	6.61	6.67	6.06	- 3
115	3.74	3.98	3.60	3.34	3.61	3.78	3.86	4.04	3.91	
120	2.52	2.54	2.37	2.20	2.23	2.36	2.53	2.74	2.82	
125	1.85	1.81	1.71	1.58	1.56	1.66	1.82	2.01	2.15	
130	1.43	1.39	1.31	1.20	1.17	1.25	1.38	1.55	1.68	
MAY					DENSITY (KG/M CU)					
70	0.43	0.52	0.68	0.88	0.91	0.91	0.96	1.01	1.06	- 4
75	2.14	2.59	3.32	4.12	4.22	4.41	4.64	4.99	5.33	- 5
80	1.05	1.26	1.55	1.82	1.83	1.98	2.09	2.30	2.49	
85	0.51	0.59	0.71	0.80	0.77	0.84	0.87	0.96	1.05	
90	2.39	2.65	3.15	3.43	3.25	3.43	3.40	3.67	3.96	- 6
95	1.06	1.17	1.33	1.41	1.36	1.38	1.29	1.34	1.38	
100	[illegible]	5.06	5.31	5.42	5.65	5.55	4.91	4.89	4.70	- 7
105	1.86	2.20	2.09	2.03	2.32	2.27	1.95	1.89	1.68	
110	8.00	9.66	8.46	7.94	9.62	9.56	8.32	7.96	6.65	- 8
115	3.68	4.39	3.72	3.41	4.17	4.24	3.85	3.73	3.05	
120	1.87	2.10	1.84	1.70	1.95	2.02	1.97	1.96	1.72	
125	1.10	1.13	1.07	1.01	1.04	1.09	1.13	1.18	1.17	
130	7.39	7.35	7.11	6.64	6.49	6.85	7.39	7.89	8.22	- 9

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
JUNE					TEMPERATURE (K)					
70	233	233	224	210	207	211	210	217	224	
75	224	221	212	198	195	198	192	193	198	
80	217	212	205	194	191	191	179	174	175	
85	208	205	198	190	189	187	173	162	158	
90	201	199	189	183	187	184	174	161	150	
95	199	198	183	177	186	184	182	172	154	
100	207	202	186	181	190	191	199	195	177	
105	229	216	204	199	204	208	226	234	228	
110	271	247	243	240	234	241	269	294	327	
115	341	303	309	307	287	297	331	375	479	
120	440	396	401	394	367	379	415	469	598	
125	546	509	488	473	461	475	509	557	623	
130	623	587	551	537	539	554	586	634	671	
JUNE					PRESSURE (N/M SQ)					
70	2.64	3.34	4.19	5.22	5.25	5.48	6.02	7.25	8.21	+ 0
75	1.27	1.60	1.95	2.30	2.29	2.42	2.63	3.21	3.70	
80	0.59	0.74	0.88	0.98	0.96	1.03	1.07	1.29	1.51	
85	2.71	3.32	3.85	4.14	4.03	4.25	4.14	4.75	5.51	- 1
90	1.20	1.46	1.64	1.71	1.67	1.74	1.59	1.69	1.86	
95	5.27	6.37	6.77	6.84	6.92	7.08	6.27	6.23	6.21	- 2
100	2.36	2.83	2.80	2.75	2.90	2.96	2.65	2.53	2.28	
105	1.13	1.31	1.23	1.18	1.28	1.31	1.23	1.18	1.00	
110	5.97	6.61	6.05	5.71	6.17	6.43	6.42	6.35	5.53	- 3
115	3.57	3.74	3.46	3.24	3.39	3.58	3.77	3.92	3.69	
120	2.40	2.41	2.27	2.11	2.13	2.27	2.47	2.69	2.76	
125	1.76	1.73	1.63	1.51	1.49	1.60	1.77	1.98	2.13	
130	1.36	1.32	1.24	1.13	1.12	1.20	1.34	1.52	1.66	
JUNE					DENSITY (KG/M CU)					
70	0.39	0.50	0.65	0.87	0.88	0.91	1.00	1.16	1.28	- 4
75	1.97	2.52	3.20	4.04	4.08	4.26	4.75	5.78	6.52	- 5
80	0.96	1.22	1.49	1.76	1.76	1.87	2.07	2.58	3.00	
85	0.45	0.56	0.68	0.76	0.74	0.79	0.83	1.02	1.21	
90	2.08	2.54	3.01	3.24	3.10	3.28	3.17	3.64	4.31	- 6
95	0.92	1.12	1.28	1.33	1.29	1.33	1.19	1.26	1.39	
100	3.93	4.80	5.14	5.19	5.22	5.30	4.56	4.47	4.43	- 7
105	1.68	2.05	2.02	1.98	2.10	2.12	1.84	1.71	1.50	
110	7.42	[illegible]	8.20	7.81	8.66	8.79	7.95	7.26	5.70	- 8
115	3.49	[illegible]	3.59	3.38	3.78	3.89	3.73	3.48	2.58	
120	1.80	1.96	1.78	1.68	1.82	1.89	1.92	1.89	1.53	
125	1.06	1.08	1.03	0.98	0.99	1.05	1.11	1.16	1.13	
130	7.10	7.08	6.85	6.39	6.27	6.66	7.22	7.78	8.15	- 9

JULY						TEMPERATURE (K)			
70	230	227	220	211	211	211	209	215	224
75	220	217	210	200	198	200	194	191	197
80	211	211	204	194	191	195	184	172	174
85	203	207	199	189	186	190	178	163	159
90	198	204	192	181	183	184	177	163	152
95	199	201	187	178	181	181	182	174	157
100	209	203	189	183	187	185	196	197	178
105	233	214	204	203	204	204	222	236	226
110	277	240	238	242	239	241	265	293	316
115	348	294	297	306	296	305	331	370	451
120	446	386	386	390	377	392	418	462	570
125	549	506	484	471	465	481	510	554	615
130	625	589	552	537	539	553	585	632	669

AUGUST						TEMPERATURE (K)			
70	227	223	219	215	215	218	213	216	225
75	219	217	212	204	200	205	200	195	199
80	213	213	207	197	192	197	190	178	179
85	204	208	199	190	187	190	183	169	165
90	195	200	189	183	185	182	179	170	159
95	192	195	183	179	186	178	180	181	165
100	200	197	187	184	191	183	191	202	185
105	227	211	205	201	204	202	216	234	228
110	282	244	244	237	232	241	261	282	307
115	369	305	310	298	281	306	331	350	423
120	479	403	403	383	360	394	422	442	537
125	569	520	495	473	461	483	512	546	603
130	636	600	561	543	543	554	583	628	665

JULY						PRESSURE (N/M SQ)				
70	2.74	3.46	4.30	5.15	5.29	5.31	5.75	7.16	8.30	+ 0
75	1.30	1.63	1.98	2.28	2.34	2.35	2.50	3.14	3.74	
80	0.60	0.75	0.88	0.98	0.99	1.01	1.03	1.24	1.51	
85	2.68	3.37	3.87	4.10	4.10	4.28	4.12	4.57	5.53	- 1
90	1.17	1.50	1.66	1.67	1.67	1.77	1.62	1.64	1.89	
95	5.08	6.69	6.97	6.67	6.76	7.16	6.44	6.10	6.42	- 2
100	2.28	3.00	2.94	2.70	2.79	2.93	2.70	2.51	2.39	
105	1.10	1.39	1.30	1.17	1.22	1.27	1.24	1.18	1.05	
110	5.88	6.90	6.36	5.74	5.93	6.18	6.36	6.37	5.73	- 3
115	3.56	3.83	3.56	3.26	3.30	3.47	3.72	3.92	3.75	
120	2.41	2.43	2.29	2.11	2.10	2.23	2.45	2.67	2.75	
125	1.77	1.73	1.63	1.50	1.48	1.58	1.75	1.96	2.11	
130	1.36	1.32	1.24	1.13	1.11	1.19	1.33	1.50	1.64	

AUGUST						PRESSURE (N/M SQ)				
70	3.02	3.83	4.43	5.28	5.49	5.46	5.51	6.34	7.03	+ 0
75	1.43	1.79	2.04	2.38	2.46	2.48	2.46	2.80	3.19	
80	0.66	0.82	0.92	1.04	1.05	1.08	1.04	1.14	1.31	
85	2.96	3.74	4.07	4.41	4.36	4.58	4.28	4.34	4.96	- 1
90	1.29	1.66	1.73	1.82	1.79	1.88	1.70	1.62	1.77	
95	5.49	7.20	7.16	7.31	7.37	7.51	6.79	6.32	6.35	- 2
100	2.38	3.14	2.97	2.98	3.10	3.03	2.81	2.68	2.46	
105	1.12	1.42	1.30	1.29	1.37	1.30	1.27	1.27	1.11	
110	5.95	7.05	6.43	6.25	6.59	6.32	6.45	6.78	6.03	- 3
115	3.67	3.97	3.67	3.50	3.58	3.56	3.77	4.08	3.88	
120	2.55	2.56	2.40	2.24	2.23	2.30	2.49	2.73	2.79	
125	1.90	1.85	1.73	1.59	1.55	1.64	1.80	1.99	2.12	
130	1.47	1.42	1.32	1.20	1.17	1.24	1.37	1.53	1.65	

JULY						DENSITY (KG/M CU)				
70	0.41	0.53	0.68	0.85	0.87	0.87	0.96	1.16	1.29	- 4
75	2.06	2.61	3.27	3.98	4.12	4.09	4.50	5.73	6.62	- 5
80	0.99	1.23	1.50	1.76	1.81	1.81	1.96	2.52	3.02	
85	0.46	0.57	0.68	0.76	0.77	0.78	0.80	0.98	1.21	
90	2.05	2.57	3.00	3.20	3.18	3.33	3.17	3.49	4.32	- 6
95	0.89	1.15	1.29	1.30	1.29	1.37	1.22	1.21	1.42	
100	3.76	5.07	5.30	5.03	5.08	5.40	4.73	4.38	4.61	- 7
105	1.61	2.20	2.14	1.94	2.00	2.10	1.89	1.70	1.59	
110	7.17	9.57	8.80	7.79	8.16	8.44	8.01	7.32	6.13	- 8
115	3.41	4.29	3.85	3.41	3.58	3.67	3.69	3.52	2.78	
120	1.79	2.04	1.87	1.70	1.75	1.80	1.89	1.90	1.61	
125	1.06	1.09	1.05	0.98	0.93	1.03	1.10	1.15	1.13	
130	7.13	7.09	6.85	6.37	6.24	6.62	7.18	7.73	8.09	- 9

AUGUST						DENSITY (KG/M CU)				
70	0.46	0.60	0.70	0.86	0.89	0.87	0.90	1.02	1.09	- 4
75	2.27	2.87	3.35	4.06	4.27	4.21	4.28	5.02	5.57	- 5
80	1.08	1.34	1.55	1.83	1.91	1.91	1.91	2.23	2.56	
85	0.50	0.63	0.71	0.81	0.81	0.84	0.81	0.89	1.05	
90	2.30	2.88	3.18	3.45	3.36	3.58	3.32	3.31	3.87	- 6
95	0.99	1.28	1.35	1.41	1.37	1.46	1.30	1.21	1.34	
100	4.09	5.47	5.43	5.53	5.55	5.66	5.03	4.56	4.59	- 7
105	1.67	2.28	2.14	2.15	2.25	2.17	1.97	1.84	1.66	
110	7.13	9.65	8.68	8.63	9.34	8.64	8.20	8.09	6.64	- 8
115	3.31	4.27	3.81	3.76	4.09	3.74	3.72	3.87	3.07	
120	1.76	2.06	1.88	1.83	1.94	1.84	1.90	2.03	1.73	
125	1.10	1.14	1.09	1.04	1.04	1.05	1.12	1.17	1.16	
130	7.56	7.48	7.19	6.69	6.51	6.83	7.36	7.85	8.17	- 9

AP =132.0   F107 =150.0

DIURNAL AND ZONAL MEAN OF MID-MONTH VALUES

SEPTEMBER — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	225	224	222	216	215	220	215	216	222
75	216	216	213	205	200	207	205	204	206
80	208	207	204	198	191	199	197	192	192
85	196	198	195	191	187	190	190	184	181
90	185	194	188	184	185	181	182	182	175
95	181	195	185	180	187	176	179	188	178
100	191	202	191	185	193	181	188	203	195
105	224	220	210	203	208	201	212	230	233
110	290	254	248	240	235	243	259	273	303
115	397	313	311	302	285	311	335	339	407
120	516	408	403	389	364	401	429	433	518
125	591	529	501	479	464	485	513	540	593
130	651	615	574	551	546	553	578	621	657

OCTOBER — TEMPERATURE (K)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG
70	226	226	223	218	212	217	217	223	231
75	213	213	210	204	200	206	209	215	222
80	199	199	198	196	194	199	204	208	213
85	184	186	189	191	191	191	196	201	201
90	173	179	183	188	190	182	187	194	191
95	172	180	183	188	191	177	181	193	188
100	187	194	193	193	196	182	187	201	199
105	226	224	215	208	209	204	210	221	228
110	303	277	256	237	235	247	256	262	285
115	423	357	323	290	282	316	332	330	377
120	543	458	414	373	361	405	427	428	488
125	606	553	509	475	463	484	508	533	577
130	664	627	583	556	546	549	569	609	645

SEPTEMBER — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	3.97	4.30	4.81	5.49	5.59	5.57	5.24	5.03	4.78	+ 0
75	1.86	2.02	2.23	2.49	2.50	2.54	2.36	2.27	2.18	
80	0.84	0.92	1.00	1.09	1.07	1.12	1.03	0.97	0.94	
85	3.71	4.02	4.36	4.64	4.43	4.76	4.35	4.00	3.86	- 1
90	1.55	1.72	1.83	1.91	1.82	1.95	1.78	1.61	1.52	
95	6.25	7.35	7.56	7.74	7.51	7.76	7.14	6.58	5.93	- 2
100	2.58	3.23	3.18	3.17	3.19	3.11	2.93	2.85	2.46	
105	1.18	1.51	1.42	1.38	1.43	1.34	1.30	1.35	1.15	
110	6.28	7.67	7.09	6.73	6.97	6.53	6.60	7.13	6.28	- 3
115	3.95	4.39	4.05	3.79	3.83	3.72	3.89	4.24	4.00	
120	2.81	2.84	2.64	2.45	2.40	2.43	2.60	2.82	2.86	
125	2.13	2.05	1.90	1.75	1.68	1.75	1.90	2.06	2.16	
130	1.66	1.58	1.45	1.33	1.27	1.33	1.45	1.58	1.68	

OCTOBER — PRESSURE (N/M SQ)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	5.28	5.31	5.42	5.67	5.57	5.55	4.87	4.11	3.56	+ 0
75	2.47	2.48	2.50	2.57	2.47	2.52	2.22	1.91	1.70	
80	1.10	1.11	1.10	1.12	1.06	1.11	0.99	0.87	0.79	
85	4.60	4.64	4.67	4.73	4.47	4.72	4.31	3.85	3.53	- 1
90	1.81	1.86	1.92	1.97	1.87	1.94	1.81	1.66	1.51	
95	6.89	7.39	7.79	8.23	7.87	7.73	7.40	7.09	6.32	- 2
100	2.74	3.07	3.26	3.50	3.39	3.12	3.05	3.09	2.71	
105	1.24	1.41	1.47	1.57	1.53	1.35	1.35	1.44	1.26	
110	6.67	7.39	7.47	7.66	7.48	6.68	6.85	7.44	6.75	- 3
115	4.28	4.46	4.33	4.23	4.10	3.86	4.04	4.37	4.18	
120	3.10	3.03	2.85	2.67	2.56	2.55	2.72	2.90	2.92	
125	2.36	2.24	2.06	1.89	1.79	1.84	1.99	2.11	2.18	
130	1.84	1.72	1.57	1.43	1.36	1.40	1.52	1.63	1.70	

SEPTEMBER — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	6.14	6.67	7.54	8.84	9.08	8.83	8.49	8.09	7.50	- 5
75	2.99	3.24	3.65	4.21	4.35	4.28	4.02	3.88	3.69	
80	1.41	1.54	1.71	1.91	1.94	1.96	1.82	1.77	1.71	
85	6.58	7.06	7.77	8.44	8.26	8.70	8.00	7.58	7.41	- 6
90	2.92	3.09	3.39	3.62	3.41	3.73	3.40	3.07	3.01	
95	1.20	1.31	1.41	1.48	1.39	1.52	1.38	1.21	1.15	
100	4.64	5.48	5.68	5.84	5.63	5.85	5.34	4.82	4.33	- 7
105	1.79	2.32	2.28	2.28	2.30	2.23	2.07	1.99	1.68	
110	0.73	1.01	0.94	0.92	0.97	0.88	0.84	0.87	0.70	
115	3.32	4.61	4.20	4.01	4.30	3.83	3.77	4.13	3.29	- 8
120	1.80	2.26	2.08	1.97	2.06	1.90	1.93	2.13	1.83	
125	1.18	1.24	1.18	1.12	1.11	1.11	1.16	1.23	1.20	
130	8.30	8.14	7.78	7.26	6.99	7.25	7.76	8.15	8.38	- 9

OCTOBER — DENSITY (KG/M CU)

LAT= KM	-80	-60	-40	-20	0	20	40	60	80 DEG	
70	8.13	8.19	8.47	9.09	9.17	8.90	7.82	6.42	5.36	- 5
75	4.03	4.05	4.16	4.38	4.31	4.26	3.71	3.10	2.67	
80	1.92	1.94	1.94	1.99	1.91	1.94	1.69	1.46	1.29	
85	8.70	8.69	8.60	8.61	8.15	8.61	7.65	6.69	6.11	- 6
90	3.64	3.62	3.63	3.64	3.42	3.70	3.37	2.97	2.75	
95	1.39	1.42	1.47	1.51	1.43	1.51	1.41	1.27	1.16	
100	5.05	5.44	5.80	6.18	5.91	5.82	5.57	5.29	4.69	- 7
105	1.86	2.13	2.31	2.53	2.45	2.22	2.17	2.20	1.89	
110	0.74	0.89	0.96	1.06	1.04	0.88	0.88	0.95	0.80	
115	3.38	4.12	4.35	4.68	4.63	3.88	3.91	4.34	3.69	- 8
120	1.88	2.16	2.19	2.25	2.21	1.96	2.00	2.19	1.97	
125	1.28	1.30	1.27	1.22	1.18	1.16	1.21	1.27	1.24	
130	9.07	8.80	8.34	7.78	7.44	7.64	8.15	8.46	8.57	- 9

NOVEMBER TEMPERATURE (K)

70	225	221	217	217	212	215	221	229	230
75	204	203	202	203	199	205	213	221	224
80	184	184	191	196	193	199	210	213	217
85	169	172	184	192	190	193	205	208	210
90	163	170	181	190	189	185	196	205	203
95	168	180	185	189	191	180	190	206	201
100	189	201	197	194	198	185	192	210	209
105	233	236	221	209	212	205	208	223	231
110	311	288	262	239	239	245	244	249	274
115	424	360	326	293	287	312	308	300	346
120	535	452	414	376	364	398	399	390	448
125	604	552	510	476	461	477	491	510	554
130	670	633	587	556	543	542	557	595	631

NOVEMBER PRESSURE (N/M SQ)

70	7.24	6.70	6.07	5.76	5.49	5.39	4.46	3.68	3.11	+ 0
75	3.32	3.04	2.74	2.60	2.44	2.43	2.07	1.75	1.49	
80	1.40	1.28	1.17	1.13	1.04	1.07	0.94	0.81	0.70	
85	5.43	5.01	4.79	4.78	4.36	4.57	4.22	3.67	3.20	- 1
90	1.98	1.89	1.93	2.00	1.82	1.90	1.84	1.64	1.43	
95	7.24	7.31	7.82	8.40	7.66	7.73	7.87	7.36	6.30	- 2
100	2.86	3.07	3.31	3.58	3.32	3.16	3.35	3.38	2.84	
105	1.31	1.45	1.52	1.60	1.51	1.38	1.50	1.61	1.36	
110	7.18	7.82	7.77	7.84	7.49	6.85	7.47	8.22	7.23	- 3
115	4.62	4.76	4.52	4.35	4.15	3.93	4.26	4.64	4.35	
120	3.32	3.21	2.96	2.75	2.60	2.58	2.79	2.97	2.94	
125	2.51	2.35	2.13	1.94	1.82	1.86	2.01	2.12	2.16	
130	1.96	1.81	1.62	1.46	1.37	1.40	1.53	1.62	1.67	

NOVEMBER DENSITY (KG/M CU)

70	1.12	1.06	0.97	0.93	0.90	0.87	0.70	0.56	0.47	- 4
75	5.66	5.23	4.72	4.46	4.26	4.14	3.37	2.75	2.32	- 5
80	2.65	2.42	2.13	2.00	1.88	1.86	1.56	1.32	1.12	
85	1.12	1.01	0.91	0.86	0.80	0.82	0.72	0.61	0.53	
90	4.24	3.85	3.69	3.67	3.33	3.57	3.27	2.78	2.45	- 6
95	1.49	1.41	1.46	1.54	1.38	1.48	1.43	1.24	1.09	
100	5.21	5.26	5.76	6.31	5.72	5.83	5.97	5.50	4.68	- 7
105	1.92	2.09	2.32	2.58	2.39	2.26	2.42	2.44	2.01	
110	0.78	0.91	0.99	1.08	1.02	0.91	1.00	1.10	0.89	
115	3.64	4.39	4.52	4.76	4.61	4.01	4.43	5.05	4.17	- 8
120	2.06	2.33	2.29	2.30	2.23	2.02	2.19	2.45	2.16	
125	1.37	1.38	1.32	1.26	1.21	1.19	1.26	1.32	1.27	
130	9.58	9.20	8.63	8.01	7.60	7.78	8.32	8.57	8.59	- 9

DECEMBER TEMPERATURE (K)

70	225	219	213	215	215	216	220	230	232
75	199	195	195	201	200	203	214	223	225
80	176	174	183	194	193	198	213	216	219
85	159	163	177	189	188	193	209	210	210
90	153	163	178	186	184	186	200	205	203
95	159	176	187	186	184	181	191	202	202
100	183	202	204	192	190	185	191	206	209
105	236	244	230	211	209	203	204	219	231
110	334	303	269	246	245	242	238	250	273
115	476	378	327	305	304	308	300	307	343
120	587	465	408	388	384	393	390	399	442
125	619	555	506	479	467	472	484	510	547
130	672	635	587	554	539	536	550	587	623

DECEMBER PRESSURE (N/M SQ)

70	8.64	7.59	6.36	5.77	5.54	5.44	4.35	3.50	2.95	+ 0
75	3.92	3.38	2.81	2.58	2.47	2.45	2.02	1.67	1.42	
80	1.60	1.37	1.16	1.11	1.06	1.07	0.92	0.78	0.67	
85	5.89	5.06	4.57	4.66	4.43	4.57	4.20	3.58	3.08	- 1
90	2.01	1.81	1.79	1.92	1.82	1.91	1.87	1.61	1.38	
95	6.89	6.80	7.24	7.92	7.44	7.78	8.06	7.18	6.11	- 2
100	2.61	2.84	3.13	3.33	3.11	3.18	3.45	3.24	2.76	
105	1.18	1.36	1.48	1.49	1.38	1.39	1.53	1.53	1.33	
110	6.60	7.50	7.74	7.40	6.86	6.80	7.50	7.77	7.07	- 3
115	4.41	4.67	4.52	4.18	3.89	3.87	4.22	4.43	4.24	
120	3.27	3.19	2.94	2.68	2.50	2.52	2.73	2.87	2.85	
125	2.52	2.34	2.10	1.90	1.77	1.80	1.96	2.06	2.09	
130	1.96	1.79	1.59	1.43	1.33	1.36	1.49	1.58	1.61	

DECEMBER DENSITY (KG/M CU)

70	1.34	1.21	1.04	0.94	0.90	0.88	0.69	0.53	0.44	- 4
75	6.86	6.04	5.00	4.47	4.30	4.20	3.27	2.62	2.19	- 5
80	3.17	2.73	2.21	1.99	1.91	1.87	1.51	1.26	1.07	
85	1.29	1.08	0.90	0.86	0.82	0.82	0.70	0.59	0.51	
90	4.58	3.86	3.49	3.59	3.43	3.56	3.25	2.73	2.36	- 6
95	1.50	1.34	1.34	1.47	1.40	1.48	1.45	1.23	1.05	
100	4.90	4.82	5.26	5.92	5.57	5.38	6.16	5.40	4.54	- 7
105	1.71	1.90	2.17	2.37	2.21	2.28	2.51	2.35	1.96	
110	0.67	0.83	0.96	0.99	0.92	0.92	1.03	1.03	0.87	
115	3.10	4.11	4.54	4.41	4.09	4.01	4.51	4.72	4.11	- 8
120	1.85	2.26	2.33	2.18	2.04	2.00	2.19	2.31	2.13	
125	1.34	1.38	1.32	1.23	1.16	1.17	1.24	1.28	1.25	
130	9.61	9.18	8.55	7.90	7.46	7.62	8.19	8.42	8.42	- 9

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